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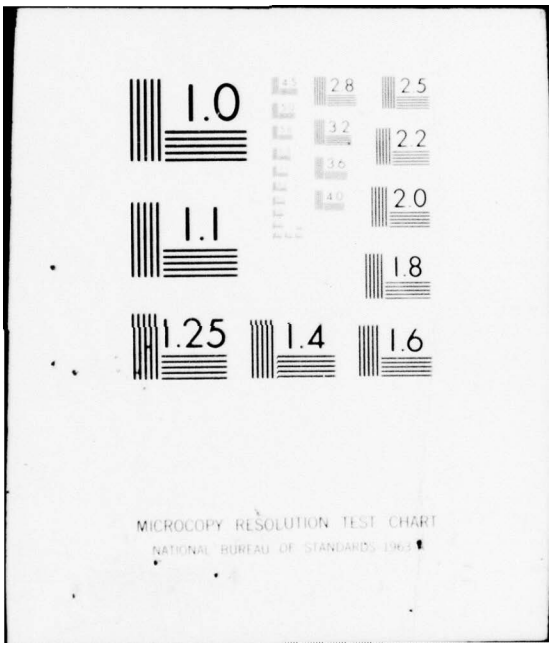
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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with certain articles prepared by, or in cooperation with, members of the scientific staffs of the United States Air Force's European Office of Aerospace Research

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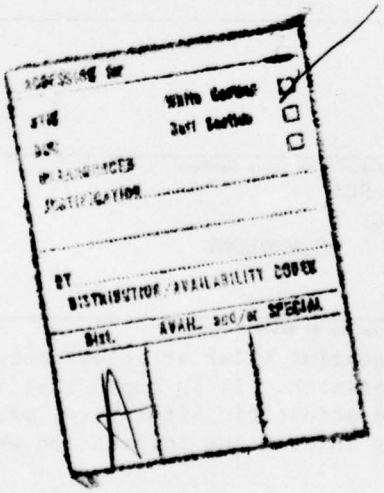

Topics reported on in this issue include:

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CHEMISTRY

MOLECULAR RELAXATION PROCESSES

Various methods exist for probing molecular relaxation in liquids following a perturbation. A significant problem is to reduce the many particle-interactions observed to the single-particle relaxation process, especially because different probes obtain different measures of relaxation. The Faraday Division of the Chemical Society, London, held a two-day symposium on "Newer Aspects of Molecular Relaxation Processes", at the Royal Institution, London, 13-14 December 1976. The Conference considered experimental methods, theoretical models of relaxation processes, hydrodynamics of rotation in fluids, and the "experimental" technique of examining motions in a computer-generated liquid.

A major topic of concern at the Conference involved the correlation function, a concept which is often difficult for the uninitiated to grasp. Indeed, several participants stated that the physical meaning of a correlation function could not be condensed into a few words.

Professor J. Clarke (Manchester) in a review paper devoted some four pages to "What is a Correlation Function?" However, we shall try to distill a succinct statement from Clarke's manuscript: The time auto-correlation function $C_B(t)$ of a molecular property of a liquid, called B, is defined as the product, $B(\tau)B(t+\tau)$, averaged over all N molecules and all time. Here, $B(t+\tau)$ is uniquely defined by the state of the system at time τ. If the value of the property B is known at some particular time, say B_1, then the product $C_B(t)B_1$ gives the average value of B at some later time t. The correlation function thus describes how some fluctuation in B persists before it is averaged out by thermal motions. The decay in the fluctuation can be characterized by a "relaxation time" or a series of relaxation times if a model is assumed. The power of using a correlation function lies in the fact that a model is not assumed. The correlation time, then, is simply the integral of the correlation function normalized by the correlation function at time zero. The Fourier transform of a correlation function is the intensity of the fluctuation as detected, say, by some spectral technique, such as light scattering, resonance Raman spectra, far infrared, Kerr decay times, etc. The question, then, is, having imposed a perturbation on a liquid, how does the liquid react?

Professor D. Kivelson (Univ. California, Los Angeles) gave the introductory lecture and reviewed the background areas. Recently-developed tools now being used to examine molecular relaxation processes include high-speed computation of molecular dynamics (i.e., the "computer-generated liquid"), laser light scattering, nuclear scattering, short-pulse spectra, resonance Raman spectra, and a new emphasis on the hydrodynamics of spheres or near-spheres in homogeneous fluids. The results appear, however, not to give direct molecular relations but, rather, more macroscopic properties. In terms of molecular rotations, for example, the problem is to reduce the experimental observations to correlation functions for rotation of a single particle, but a number of uncertainties remain. Various theoretical models have been proposed relating the roughness of the molecular surface to the amount of stick or slip as the molecule rotates. These models suggest that the correlation time is linear with the viscosity through the equation: $\tau = \tau^\circ + K\eta$, where K is a constant given by theory. Kivelson raised a number of questions: If the correlation time is proportional to viscosity, does it hold near the critical point of a fluid? If the viscosity is altered near the critical point, is the correlation time affected? The τ°'s seem to exist in solutions, but not in neat liquids; are these observations firmly established, and if so, what do they mean? In depolarized light scattering, which is related to molecular rotation, a background line exists which contains as much intensity as do the peaks; is this due to some type of cross coupling or to slow molecular rotation? It was noted that in analyzing rotational data there are difficulties in comparing the results of one experiment with another because different averages of molecular rotation are observed.

J.M. Deutch (MIT) outlined three theoretical problems in dielectric

relaxation: What is the relationship between measured dielectric constants as a function of frequency, $\varepsilon(\omega)$, and the equilibrium-time correlation function? How can the measurements that involve the relaxation of many interacting particles be reduced to a single-particle equilibrium-time correlation function? If the prior issues are resolved, can $\varepsilon(\omega)$ distinguish among various models? At the moment, these problems are not resolved.

J.H. Freed (Cornell) discussed some work in electron spin resonance (ESR) where the molecules are tumbling slowly. He finds that the diffusion constant is inversely proportional to the viscosity (both measured as a function of frequency) but is uncertain of the underlying reasons. Further, as far as ESR is concerned, there are no rotational anomalies in the critical region (see the question raised by Kivelson).

J. Clarke (Manchester) raised the question of the physical significance of the theoretical proportionality between the single-particle and the many-particle equilibrium-time correlation functions which may hold only in the diffusional limit.

G. Williams and his collaborators at the University College of Wales have been studying the dynamic Kerr effect, which is the change in the normalized birefringence with time. Two systems investigated gave similar results at low temperatures, consistent with a "fluctuation-relaxation" model (wherein the solute moves through large-angle steps) and inconsistent with the small-angle rotational model. At higher temperatures, however, one system diverged and became more consistent with the small-angle rotational model. The change from one model to another may be typical of viscous liquids and amorphous solid polymers.

B.J. Berne (Columbia) has been comparing the correlation function calculated from hydrodynamic theory with experimental results obtained from "computer fluids", which may involve 108 spheres undergoing 250,000 collisions. If the hydrodynamic theory is forced to give the correct initial and long-time decay, it predicts strong oscillations in $C_\omega(t)$, but the oscillations do not appear to occur in rough sphere fluids. In his paper, he concluded that either the computer experiment gave erroneous results or that the hydrodynamic model is not applicable to rotational relaxation in spite of its success in translational motions. In his oral presentation, he contended that the computer work is not in error; the problem lies in the hydrodynamic theory, which does not properly predict the correlation function of rotation at long times. The reason for the discrepancy is not clear.

G. Searby (Univ. Nice) compared the predictions of depolarized light scattering with experimental results. Light scattered with the same polarization as the incident light contains information about isotropic fluctuations in the fluid, whereas depolarized scattering contains information about anisotropic fluctuations arising from molecular reorientations. In the VH (vertical to horizontal) scattering geometry, where the incident light is vertically polarized and the scattered light is horizontally polarized, only the transverse hydrodynamic modes, or shear waves, are able to couple with the anisotropy of the liquid. The extent of coupling is given by a parameter R. At low and intermediate values of R, theory and experiment agree, but not at high values of R, which correspond to a supercooled liquid approaching the glass transition temperature. In the HH (horizontal to horizontal) geometry, the transverse velocity gradient cannot contribute to scattering, but coupling with the longitudinal gradients is permitted. Again, there are difficulties when R is large because the theory predicts different responses and the intensity of scattered light is very weak.

R. Pecora (Stanford) reported on the single particle correlation time, τ_{sp}, which can be obtained from the depolarized Rayleigh spectra by using an equation which contains the effective static and dynamic correlation functions. The parameter τ_{sp} varies linearly with the solution viscosity through $\tau_{sp} = K\eta + \tau_{sp}^{\circ}$, where K can be calculated from the slip hydrodynamic model and determined experimentally. Even though the experimental samples have quite different correlation functions, they all show the same dependence of τ_{sp} on solution viscosity. M. Davies (Univ. College of Wales) then raised the question of whether a molecular or a bulk viscosity should be used. The general

opinion was that even though single particles are rotating in a viscous liquid, the bulk viscosity is the proper parameter. When a polymer is added, however, one must take into account the viscoelastic response of the polymer at the frequencies of the response. Deutch raised the question of whether there was a transition from slip to stick in the hydrodynamic models in attempting to obtain single-particle parameters. Pecora indicated that no transition was required.

J.M. Vaughan (Royal Signals and Radar Establishment, Malvern, UK) stated that the use of a multipass Fabry-Perot instrument helps clean up the background scattering so that the fine detail of the Raman line can be detected in liquid crystals and, thus, different parameters from different portions of the line can be extracted and, further, the line width below 1 MHz can be examined. The technique also works with normal liquids with very low scattering.

T.A. Litovitz (Catholic Univ. of America) measured the depolarized light scattering from a number of symmetric liquids, such as the rare gases, methane, and CF_4. By use of a scaling parameter, the intensity of scattering can be plotted against the scaled wave number to produce a single almost linear curve over four decades of intensity, especially in the high-frequency range. This observation can be interpreted in terms of a two-component mechanism; a long-range-dipole-induced dipole, and a short-range mechanism. To separate these two effects, long-wavelength infrared line shapes that are controlled by the short-range mechanism can be examined. After scaling, data obtained from the IR line shapes superimpose onto the light-scattering intensity curve at high values of scaled frequency, which means that the short-range anisotropy induction mechanism dominates the high frequency of scattering.

In a separate presentation, Litovitz described the rotation of a benzene molecule in its own plane (like a wheel spinning about its axis) or out of the molecular plane (like a flipped coin). In the first case, rotational velocity should be independent of viscosity, but the second case does depend on the viscosity. These two cases require different hydrodynamic models to explain the effects.

T. Dorfmüller (Bielefield Univ., West Germany) finds that the hypersonic sound velocity obtained from the polarized light scattering of simple liquids can be fitted by a single relaxation curve relating the velocity to the Brillouin shift frequency. Measurements were also made at a variety of temperatures to determine the relaxation strength and the relaxation times as functions of temperature. The relaxation processes appear to correspond to a translational-vibrational energy transfer involving the lowest or the next-to-the-lowest vibrational level. Information on inelastic collision cross section, intermolecular repulsion, and the ratio of the "bulk viscosity" to the shear viscosity can also be obtained from the temperature dependence of relaxation time, provided certain assumptions are made. The "bulk viscosity" exists only for polyatomic gases and for liquids. It accounts for the difference between the equilibrium pressure (after rotational relaxation has occurred) and the kinetic pressure (before rotational relaxation has occurred) when a sound wave passes through the fluid.

J. van der Elsken (Amsterdam) examined the far-infrared rotational line widths of *HCl* dissolved in argon to obtain information on the rotational relaxation, which is sensitive to local anisotropic density fluctuations. The derived equations accounted for the experimental observations.

A.D. Buckingham (Cambridge) provided a short overview of the conference: a scientist can focus his attention on three distinct domains--that of the molecule itself, the interactions of molecules with one another, and the condensed phase itself--the last, of course, being the most difficult. The condensed phase can be described in terms of noninteracting molecules, molecules with only a small overlap, or a system wherein the identity of the molecules is lost. Each of these regions has advantages and disadvantages in terms of our ability to analyze the situation in theoretical and experimental terms. One conclusion that can be reached from the conference is that different experimental techniques need to be combined and exploited in both the gaseous and solid states to obtain information on relaxation phenomena in the condensed phase. A particularly valuable "experimental" technique

that is being pursued by a number of investigators is molecular dynamics--the investigation of computer fluids--which will be of enormous benefit to our comprehension of the condensed phase. The proceedings of the Conference will be published as a Faraday Society Symposium No. 11 in May 1977. (L.H. Peebles, Jr., ONR, Boston)

COMPUTER SCIENCE

REPORT CARDS FOR COMPUTERS

The full title of the conference held in Stresa, Italy on 4-6 October was "The Second International Workshop on Modeling and Performance Evaluation of Computer Systems". The sponsors of the meeting were IRIA (Institut de Recherche en Informatique et en Automatique) and IFIP (International Federation of Information Processing Societies), and the organizers were H.J. Helms, H. Fangmeyer and J. Larisse of the Joint Research Center of the European Communities (Ispra Establishment). The first of this series of proposed annual meetings was held in August 1974 in Rocquencourt, France.

The town of Stresa, located about 50 miles northwest of Milan on Lago Maggiore, is a popular European summer resort which generally affords a superb view of the Italian Alps. However, the much-publicized summer drought from which most of Europe had suffered was brought to a thunder-crashing end the day before the conference. The record-breaking rains, which lasted for three days and caused widespread flooding in Milan and most other parts of northern Italy, necessitated several last-minute changes in the program due to the impossibility of travel and volunteer emergency service by some of the Italian participants.

Nevertheless, the meeting was well attended by more than 185 registrants from continental Europe, the UK and the US. A total of 31 papers were presented in the three days--7 invited papers and 24 contributed.

As one might infer from the fact that major international conferences are devoted to the subject, the assessment of the performance and efficiency of contemporary computer systems is a very difficult problem. In the early days of electronic digital computers, all computers operated as "batch processors" whereby the total machine resources were focused for relatively long time periods on one particular computing task. Jobs were processed sequentially, not concurrently as in present-day multi-processing systems. In such a batch processing environment, if the computer's central processing unit (CPU) was active, it was rather obviously performing useful work on a particular job. Inactivity of the CPU generally indicated a need for more high-speed core storage, and the data processing manager could do a simple cost-benefit analysis to determine whether or not to invest in more hardware in order to increase the system throughput. With only one task at a time to worry about, the computer's operating system software (i.e., resource management software) was relatively simple.

In contrast, many of today's third-generation systems typically process dozens of jobs simultaneously, spending only milliseconds at a time working on any one job before switching to another. In these systems, the bookkeeping responsibilities of the dynamic resource allocation software are truly staggering. The bookkeeping *per se* becomes a very large computing job which competes for time and resources with the "real" jobs that the system is trying to service. The old measure of efficiency--CPU utilization--now conveys very little information regarding the amount of "useful" work being done, since much of the CPU's time is being taken up by what is termed "system overhead".

The purpose of the extensive research activity in computer systems modeling is to develop analytical models which can be used for performance prediction. On the experimental side, both hardware monitors (actual electronic devices) and software monitors (special monitoring programs) are used to gather empirical data against which the analytical models can be tested.

Although in principle one could model or simulate the dynamics of even the most complex of modern computer systems, such microscopic modeling would involve time increments of nanoseconds and would be totally impractical as a method of macroscopic performance measurement. In much the same way that statistical mechanics

provides the bridge between molecular dynamics (microscopic) and thermodynamics (macroscopic), statistics and stochastic systems theory are the proper mathematical tools for developing macroscopic measures of computer system performance.

In order to predict the performance of a computer system analytically, it is obviously necessary to characterize in some way the typical workload which the system will encounter. In a multiprocessing system it is necessary to know, for example, the relevant statistics regarding the size of programs, the basic functions of the programs (e.g., scientific number crunching or commercial file sorting), the amount of storage required by the programs, etc. Several of the papers discussed methods for gathering such characterization statistics and the difficulties encountered in attempting to reduce the enormous volumes of data gathered by monitoring a system for days or weeks to a tractable and useful set of workload characterization parameters.

Y. Bard (IBM Cambridge Scientific Center, US) presented an excellent opening paper entitled "A Characterization of VM/370 Workloads" (VM = Virtual Memory). This characterization technique, which Bard claims has been in use by IBM Service Engineers for nearly a year, was designed to provide the input to a previously developed analytic model which predicts the performance of proposed VM/370 configurations. Specifically, the model is intended to estimate the utilization of various hardware components such as main CPU, storage devices, output devices, buffers, etc., to determine transaction and response times, and to predict total system throughput. For existing installations, the workload characterization which Bard described is easily obtainable from measurements on the system's actual working environment. In addition to its use as input to an analytic model, the workload characterization is also of value to the data processing manager in identifying those users who consume the critical resources of the system. Still another use of workload characterizations is in quantitatively comparing the computing requirements of different installations.

One of the best delivered papers at the Conference was that of H. Gomma (Imperial College, London): "A Modeling Approach to the Evaluation of Computer System Performance". In this, Gomma considers two distinct modeling approaches--statistical regression and system simulation--and presents a method of combining their use in a hybrid modeling technique. Three levels of successively greater detail are involved in this scheme: the Workload Model, the Load-Adjusting Model and the Memory Management Model. These three levels can be thought of as successively improved approximations to the actual logical and structural relationships in the system. At the crudest level (the Workload Model), regression analysis provides a quick-and-dirty model of gross system performance. To refine the detail, simulation models are then used to dynamically model the more microscopic operations within the system. Gomma claims to have had reasonable success in estimating the batch-mode performance of the CDC 6000 computer system at Imperial College (i.e., the model estimates are within 30% of the actual system measurements). However, since this work was carried out under very well-controlled conditions and for an existing system configuration running in batch-mode, the present model is admittedly inadequate for more general system performance forecasting.

The mathematical discipline of queuing theory, which is concerned with problems of congestion in networks, provides a very natural tool for the modeling of computer systems. The basic idea is that the system consists of an interconnected network of service points (e.g., the CPU, high-speed core storage, input/output devices, buffers, etc.) through which user programs and data must flow in the course of program execution. Queuing theoretic models provide the proper bridge between the microscopic events which take place deep in the bowels of the computer system and the sought-after macroscopic measures of performance. It is not surprising, then, that well over half of the papers at the conference dealt either explicitly or implicitly with queuing models. Most of these papers dealt only with certain subsystems or subproblems such as job scheduling strategies, and did not attempt to model the total system.

One example of a queuing theoretic subsystem model was that of G. Fayolle and M. Robin (IRIA-Laboria), "Optimal Queuing Policies in Multiple-Processor Systems", who examined a hypothetical computer with two coupled central processing units. The "queuing discipline" considered was first-in-first-out with jobs arriving in a Poisson stream, exponentially distributed service times and queues of finite capacity. Jobs were permitted to "jockey" from one queue to another to expedite service. The problem which the authors addressed was that of determining the optimal jockeying policy which should be adopted to minimize a certain cost function. A somewhat similar model, which seemed to provide more definitive and practically useful results, was that by M. Reiser and A.G. Konheim (IBM, Yorktown Heights): "Queuing Model of a Multiprogrammed Computer System with a Jobqueue and a Fixed Number of Initiators".

Most of the papers and discussions of system monitors dealt with so-called software monitors which are special programs whose function is to provide a record of the dynamics of system resource utilization during actual workload operation. One notable exception to this was the paper by Y. Bekkers and B. Decouty (Université de Rennes, France): "A Versatile Programmable Hardware Monitor". The basic idea in the presentation was that, with the use of a mini-computer as a controller, a standard hardware monitor could be made into an adaptive monitor which could, via a feedback loop, send useful information to the central CPU, thus enabling dynamic modification of the performance of the main computer system. The authors referred to such a mini-computer controlled monitoring system as a hybrid monitor.

The Proceedings of the Workshop are to be published by North-Holland Publishing Co. whose US distributor is American Elsevier Publishing Co.
(William J. Gordon)

ONRL REPORTS

See the back of this issue for a list of current abstracts.

THE EUROPEAN COMPUTING CONFERENCE ON SOFTWARE SYSTEMS ENGINEERING (EUROCOMP '76)

EUROCOMP '76, held in September in London, was actually two conferences run in parallel, Computer Performance Evaluation and Software Systems Engineering, the latter being the latest of several of its type to be held in Europe. The first of this series was a NATO-sponsored conference held in 1968 under the title "Software Engineering Techniques", a term used to refer to the many aspects of computer software methodology and production.

In all, some 72 papers were presented at EUROCOMP '76 over a three-day period. Billed as two conferences for the price of one, the number of business people and software house representatives present was in itself a reflection of the urgent requirement in industry to reduce the high cost of designing and producing software systems.

Unfortunately, most of the papers presented in the software engineering program focused on narrow aspects of the software design problem. Even those which described program development systems covered only some facets of the total software engineering process, i.e., the steps of problem definition, software specification, program implementation and system verification. What was missing was a much-needed session on the overall architecture of program development systems.

The session on new approaches to system structuring included papers which described structuring aspects of operating systems, languages, compiler generators, and problem solvers. The most significant paper in this session, "Hierarchical Structure in Operating Systems" by G.H. MacEwen (Queen's University, Kingston, Canada) provided a theoretical framework for defining the components of an operating system and their hierarchial relationships. The operating system characteristics considered in MacEwen's model include hierarchy, transparency of access, descendancy of access, directivity of relations, and level distribution. These properties were then combined into a hierarchical model which provided a useful framework for describing and designing operating systems.

The session on software management included papers on project management, the international software market, and the high cost of programming languages. The first paper, "The Control of Systems Design for Large Projects" by Dr. F. O'Brian (PA International Management Consultants, Ltd., UK) provided a simple outline of the design, integration and implementation phases of a software project. One of the more useful comments made in this paper was that maximum use of high level tools should be made to postpone as long as possible the binding of logic decisions to machine code. This procedure allows easier testing at early program design phases in logical and more understandable forms.

The last paper scheduled in this session but not presented was "The High Cost of Programming Languages" by C.A.R. Hoare (Queen's University, Belfast). It examined the significant factors that contribute to the costs of programming. These include organization (changes), program design, program construction, error (correction), change (improvements), running costs, software procurement, and delay (in delivery). The various factors specific to programming languages which contribute to high costs were then discussed, revealing in many cases the bias of the author. Some of the languages compared in this paper were COBOL, FORTRAN, PL/1, ALGOL, LISP and PASCAL. In most cases ALGOL and PASCAL were considered superior, but the author provided only subjective evaluations to support his assertions.

The session on interface specification included several papers which addressed problems of defining program module interfaces and automatically generating programs. "Module Interface Description Language" (MIDL), by E.P. Gord and M.J. Mahon (Burroughs Corp.) described a specification language which allows the description of the data, parameters and entry-point interfaces of a modular program. The description (in MIDL) is then compiled to check for interface consistency and is subsequently employed to ensure use of those pre-defined interfaces when modules are separately compiled in their normal source language.

The last of eight papers in this session, "Automatic Generation of Programs", by Noah S. Prywes (Univ. of Pennsylvania) consisted of a progress report on his current research. The paper briefly described the latest version of his module description language and the methodology for generating a single program module (in PL/1) using the MODEL processor. Some of the recent research on MODEL is aimed toward automatic partitioning of the data description statements and associated requirements to allow production of multiple but integrated program modules.

The papers in the remaining sessions (systems reliability, languages and operating systems, adaptability and portability, and testing and validation) were principally applications oriented. They described systems implementation problems, lessons learned and, in a few cases, the software engineering practices applied.

Lacking throughout all the sessions, however, was the commitment to integrate and apply software development tools to general problem areas such as banking, insurance, communications and manufacturing. Integrated software development systems still seem to be awaiting the refinement of module partitioning concepts and more compatible system specification and implementation languages. In general, EUROCOMP '76 provided a useful forum for exchange of ideas among business and software-house representatives and in some cases insights into current software engineering research activities.
(LCDR David C. Rummler)

STANDARDIZATION OF REAL-TIME OPERATING SYSTEMS

The International Purdue Workshop on Industrial Computing Systems was founded at Purdue University and is the leading forum for developing computer standards for the process control community. In its European Branch there are two very active technical committees that are developing requirements and standards for long-term procedural languages and real-time operating systems. In the US, there exist similar Purdue America technical committees, whose efforts in these areas have been less successful and partially impeded by marketing-strategy reservations of computer-

vendors and the large user commitment to FORTRAN and PL/1 programming languages.

The Technical Committee (TC-8) on Real-Time Operating Systems (RTOS) is currently tasked to consider the definition, construction and use of an RTOS for process-control applications such as steel-plant or nuclear reactor control. Specific goals assigned to TC-8 are to make RTOS construction more efficient and economical and to attain maximum reliability and portability through the development of system-design guidelines and machine-independent concepts. The fundamental difference between an RTOS and a conventional operating system is that the RTOS supervises tasks that must co-operate in time-critical sequence as opposed to supervising essentially independent tasks that maximize the use of system resources (disc, printer, card reader, etc.).

TC-8 is composed of three sub-groups currently engaged in defining an open-ended model of an RTOS which can be expanded or reduced to suit a particular application. The "kernel" sub-group is taking a bottom-up approach (hardware to user) to define the RTOS kernel (basic features) based on the concept of a virtual machine. The architecture sub-group is defining the layers above this kernel using a top-down approach (user to hardware) which incorporates the needs of a potential RTOS user and the process-tasking requirements of the Technical Committee (TC-3) on Long-Term Procedural Language (LTPL). A third sub-group is being formed which will deal with the support requirements for computer networks in an RTOS.

In defining the basic RTOS structure TC-8 chose a hierarchical approach which consists of multi-levels of abstraction. The highest level includes the more complex features and is the layer closest to the application processes. The kernel (the lowest layer) provides an arbitrary number of pseudo-processors and an appropriate virtual instruction set by multiplexing physical processors.

A process-state model has been defined by TC-8 which specifies the primitives that must be supported by the kernel dispatcher. The three states which have been defined at the kernel level are: Running--a process allocated to a virtual processor; Ready--a process competing for a virtual processor; and Blocked--a process not competing for a virtual processor (waiting for a specified condition to become true as a result of a hardware interrupt, a message arriving in the process message buffer or a shared data structure access).

Other elements of an RTOS being defined by TC-8 include high- and low-level process communication and synchronization primitives, resource management facilities and system construction concepts. Some of the facilities and functions determined necessary in the higher levels of construction include device drivers, clock-time access alarms, allocation and de-allocation of basic resources, file handling, process creation and deletion, synchronization and communication, virtual memory, software constructors/translators, system generation utilities, operator interaction, and error handling.

TC-8's efforts have until recently been somewhat limited by the low level of EEC support. A favorable decision by the EEC Council of Ministers this spring to fund a two-year real-time technology development effort should improve TC-8's rate of progress. *(LCDR David C. Rummler)*

ELECTRONICS

GOALS-ORIENTED RESEARCH: A VISIT TO STL

A jingle might go: What in the US is Bell, in the UK is STL. There is a marked parallel between the research activities at the Standard Telecommunications Laboratories at Harlow, England and Bell Telephone Laboratories in the US. There are also differences.

The Harlow Laboratory is the largest of four research organizations within STL, with a fifth in development. Other labs are located at Paris, Stuttgart, and Madrid; Rome is the site of the new laboratory. It is the mission of the Harlow Lab to serve both as the center of corporate research, with the standard role of looking at future materials and products, and as a contributor

to direct operations when called upon by the operating divisions. Accordingly, STL scientists have responded to calls for assistance even in South America, with on-site diagnosis. The need to be "relevant" is part of management philosophy, and new employees are gently, but firmly, reminded that their laboratory is not an academic institution; each staff member is called an engineer. Reportedly, researchers respond well to this philosophy as they find satisfaction in seeing the fruits of their labors in tangible products.

An area which demonstrates the mix of science and technology is cable development. The Research Laboratory has played a large role in the corporate movement from copper to aluminum cable, including such seemingly mundane efforts as development of optimal techniques for joining, always a problem with aluminum. The monetary value of this effort is reported to justify the operation of the Laboratory for a considerable period of time. Another important conventional communication link provided by STL is submarine cables with submerged repeaters.

Developing optical cables is a different story, and now involves much of the Laboratory's current effort. The Laboratory has developed glass-fiber technology to the point that it began production in November 1976.

The optical characteristics of the fibers are, of course, central in importance. STL views its success here as a logical continuation of its experience in semiconducting materials, which substantially exceeded experience in glasses. The glass is chemically-vapor-deposited on the inside of a silica tube which is collapsed under heat (originally in flame; more recently in a small electrical heater) and drawn to fiber. $GeCl_4$ is introduced to modify the refractive index; B is added as a glass former. The drawing is precise; the diameter is controlled to $\pm\frac{1}{2}$ μm in 1 km lengths. The optical characteristics have been designed to match input from light-emitting GaAs diodes (LEDs) at 900 nm or from lasers at 850 nm. The graded-index silica fiber produced has losses of 3.5 to 4 dB/km at GaAs wavelengths with dispersions of less than 1 nsec/km. Occasionally a Gee-Whiz fiber is produced--1 dB/km. For less demanding applications, fibers with step-index profile can be made. To preserve the high initial tensile strength of the silica fibers, they solution-coat with silicone resin or Kynar. A thick polypropylene coating for mechanical protection results in a 1 mm o.d. Standard fiber lengths are 500 m and 1 km. Once produced, the optical fibers are packaged into cables containing bundles of two to eight fibers plus a central strength member and the assembly sheathed in polyethylene followed by an outer steel armoring.

The basic cable design is one with eight fibers. If a smaller number of optical paths is desired, dummy fibers are used in the cable lay-up. STL quotes a 5 dB/km loss for packaged cable and feels that their packaging techniques allow them to produce cable with the same loss as the original fiber. Residual attenuation is largely due to Rayleigh scattering. It is interesting to note that the breaking of a fiber does not necessarily signal the end of its operation. Assuming no displacement of the two ends at the break, the break merely adds about 3-dB attenuation to the optical transmission. STL quotes 2% strain to fracture as opposed to other cables available at 0.2 to 0.4%. Their investigations have included a wide variety of testing, some to US Military Specifications. For instance, the cable can withstand hundreds to thousands of hammer blows with energies of a few foot-pounds applied at the rate of one per second, although when the hammer blows are applied at higher energy levels of 5 to 10 ft-lb, the cable fails in a few blows. The fibers are themselves strong; inadvertent winding around 10-cm pulleys has been tolerated, and reeling is the common packaging technique. The STL's attention to mechanical strength is intentional, for field operation imposes the requirement that these cables should be able to withstand a variety of punishments, including the heels of field technicians, dropped hammers, etc. STL hopes to deliver 50 km of cable in 1977 requiring production of about 500 km of optical fiber.

Fiber optic development lies in the Materials Division of the Materials and Components Laboratory, under the direction of J. Evans; C.H.L. Goodman, who is the scientific liaison to Evans, served as host for our visit

to STL. Other activities in the Materials Division include the development of thick- and thin-film hybrid circuits (in cooperation with the STL production facilities in Paignton, Devon), research on inks and substrates with emphasis on non-noble metal conductors, capacitor development (also in cooperation with Paignton), and group testing and reliability of electromechanical contacts for switching. Goodman stressed the surprising amount of science that is involved in a seemingly routine study of electromechanical contacts; in fact, application of quantum mechanical methods is being explored here.

Within the Materials Division a Materials Evaluation Centre acts as production line troubleshooter for all ITT (International Telephone and Telegraph) manufacturing facilities. The Centre undertakes consultation on any materials problems encountered on ITT production lines on a worldwide basis.

Electro-optical devices are a major concern of the Components Division. Although STL developed the first LED display in 1968, they failed to capitalize on the market. Four years ago an infrared image converter consisting of an array of 192 LED elements, each 2 mil square and separated from its neighbors by 0.5 mil and using a total drive current of 0.25 A, was developed. LED performance has exceeded expectations. A night-vision telescope is another application. GaAsP LEDs with MOS (metal oxide semiconductor) memories have been developed for alphanumeric displays in such applications as air traffic control, airborne applications, etc.

The primary emphasis of the Display Group is with liquid crystal displays. These are to be produced and will be coupled with MOS memories to make alphanumeric displays and word modules. The Group's work has been aimed at understanding the SiO alignment layer in twisted nematic displays. If the SiO is evaporated onto a substrate at angles of incidence less than 15°, the molecules of the organic liquid used in the display align along the direction of incidence for the SiO. If the angle of incidence for the evaporated material is greater than 20°, the organic molecules then align perpendicular to the direction of incidence of the SiO. These alignment characteristics are the result of short-range order in the SiO layer deposited at angles of incidence lower than 15° which yields a needle or spike structure in the deposited layer. The thickness of the SiO layer used at STL is 200 Å, and the layer is corrugated at the 5-10 Å level. Al_2O_3, MgO, and CaF_2 have also been tested. The nematic liquid used is, in itself, a good solvent requiring a special inorganic (glass) container.

GaAs-GaAlAs solar cells, formed by liquid phase epitaxy, are being studied. These cells can be operated under conditions when light is focused to intensities equivalent to 1000-2000 suns. They operate with a small fall-off in efficiency to 250°C. STL plans to make a device termed a "solar eyeball" which will use wasted solar energy to find and track the sun throughout the day. This "solar eyeball" is to be constructed of cheap materials and be maintenance-free.

STL is an acknowledged leader in the area of injection lasers. They produce these for both military and communications applications. The purely military applications include devices for rangefinders, weapons and illuminators. Communications applications, which are also of military interest, include interference-free data links, local area TV links, and high-capacity trunklines. Their low-power devices are the conventional double heterojunction GaAs-GaAlAs structure. These devices have a 5-50 μm core diameter with a 0.2 μm GaAs active layer. Because these low-power devices are made for communications applications, one important characteristic is cw device lifetimes in excess of 10,000 hours. Testing indicates 2-8% failures per 1000 hours in earlier operation, better later.

Research at STL has emphasized finding methods of identifying devices which will not meet specifications and determining manufacturing techniques which produce a high yield of long-lived devices. They attribute device-aging difficulties to dislocation structures in the active layer, which eventually lead to black-line degradation, and they use optical examination to identify devices which are likely to fail early. Their success with this method was demonstrated in a life-test of 20 lasers. This test-group was selected by optical techniques; after an initial burn-in period, 19 of the lasers operated

with stable output powers for over 10,000 hours. The one rogue device was subsequently examined, and it was determined that the laser should have been rejected initially on the basis of its optical characteristics. Late service-failures are probably due to strain introduced by the oxide layer. While STL makes its lifetime tests at room temperature, the Post Office Research Laboratory at Ipswich performs accelerated tests at 90°C.

Injection lasers for military applications are usually pulsed, high-peak power, low-duty cycle devices which are typically single heterojunction devices. These devices have a thicker active region (about 2 μm), higher threshold currents, and are now limited to a maximum temperature of 60°C. At higher temperatures optical confinement of the beam becomes a problem. STL is developing a five-layer structure with a localized gain region (LGR) which they feel will produce devices with better high-temperature and high-duty cycle characteristics. The LGR is only 700 Å thick and STL would like to make it as thin as 300 Å. This region helps in optical confinement of the beam. STL uses liquid-phase epitaxy for growth of all laser devices because both vapor and molecular beam epitaxy create traps which degrade device performance. Using a rotary crucible technique to obtain accurate temperature control, they are able to achieve the specified layer thickness reliably and at the same time obtain good surface characteristics. In growth of the LGR devices, their yield is 40%, with layer thicknesses in the 600 to 1000 Å range. The proper layer thickness is critical in order to prevent self-destruction of the device through having too much energy at the output face. These high-powered lasers have a width of 250 μm and produce 5 MW/cm^2 with 1% duty cycle. For battlefield illumination eight lasers are fed into a rectangular optical fiber, and ten such units combined give an output beam diameter of 1 mm with 300-W peak power. The maximum duty cycle for these arrays has not been determined.

Silicon technology is still an important research area. In the fabrication of patterns for integrated circuits there has been no fundamental change in photolithography, but over the past few years there has been a continuous reduction in element size as a result of large-scale integration efforts. Further reduction in the size of these circuits will require new methods of masking the devices. Some of the problems being studied by this group include the use of soft x-rays to expose resists, plasma-etching and conformal coating of the devices once etched. They have found that plasma-etch rates in silicon oxides are faster than in pure silicon and that they can also etch aluminum and nitride layers. They can directionally control the plasma etch to 1-μm resolution and to depths of 2 μm; no "mousehole effect" is discernible--the walls are straight with no undercut noticeable. STL has evaluated coating techniques and found that thermal oxide and evaporative deposition are adequate for silicon oxides but that thermal evaporation is inadequate for aluminum because it leaves crevices which reduce device yields. They feel that chemical-vapor-deposition of Al using a trinitrobutyl-Al complex does not exhibit these problems, but for unexplained reasons this method does not always work and is not therefore ready for production.

Biophysics is the newest area in the materials and component laboratory. The philosophy here is to learn the lessons biology has to teach in fabricating devices. The work is in its early stages and is starting with studies of membranes which are specific in their passage of particular enzymes. One possible application for such a filter would be as a detector for contaminants. Biophysics is a rather small effort and STL hopes to reap benefits from advances expected over the next fifteen years.

An area of large applications potential involves leachable glasses. The developments here started with a scientific curiosity concerning the rate of solution of glasses in liquids, including water. In a classical set of events, STL has now produced a variety of glasses which have solution rates that may vary over 15 orders of magnitude, depend on environmental pH and temperature, can carry selected additives (e.g., K), and dissolve with no residue and little side-leaching. The major market intended for these glasses is agriculture; tailored, long-lasting fertilizers have been produced and successfully tested on grasses. Other

applications include herbicides, time-release of fungicides for oil spill control, and reduction of algae. Medical applications (e.g., dressings) are also envisaged.

Another line of interest for glass is its possible importance in the electronics industry. It could be used as a substrate material for electronic components with its thermal expansion coefficient being easily matched to semiconductors and metals. STL has also developed the techniques necessary to produce channel plates for image intensifiers from lead-free glass.

STL maintains an advanced high-pressure laboratory, used primarily by several academic institutions. Goodman is convinced that the use of pressure as an available parameter will find wide and increasing use in the future, in a manner similar to the way that cryogenics has pervaded laboratories. One particularly attractive study in the laboratory, using apparatus capable of measuring Hall voltages at pressures up to 100 kbar, demonstrated that Ge becomes very similar, at high pressures, to Si at ambient pressure, and GaAs to GaP.

The breadth of the activities in the Materials and Components Laboratory, which numbers about 200 engineers, is obvious. The remainder of STL's Harlow Laboratory lies in the Telecommunications Laboratory, with its 350 engineers. Assuming equivalent scope and abilities there, one must arrive at the conclusion that the STL Laboratory is truly first-class. [James H. Gorrell (EOARD), Alfred Nedoluha (USARSG), and Al Sosin]

CHELSEA AMORPHOUS SEMICONDUCTORS MEETING

This annual meeting was first convened several years ago by Professor A.J. Jonscher (Univ. London) as an informal gathering of British scientists interested in amorphous semiconductors. By now this affair has become somewhat traditional and much more international in scope, but the organizers still endeavor to maintain an informal atmosphere with a reasonable time after each paper reserved for informal discussion. The size of the meeting has hovered around 100 participants for the last couple of years. Officially, the meeting is open only to those with invitations, and the organizing "committee" consists of one or two people who rotate from year to year. This year's conference, which was held at Chelsea College (London) on 20 and 21 December 1976, was organized by Professor W.E. Spear and Dr. P.G. LeComber (Univ. Dundee).

Both the size and format of the meeting were conducive to informality, but I was mildly disappointed at the limited time for discussion which followed most of the talks. Speakers were instructed to end promptly in order to allow ample time for discussion, but given the informal atmosphere of the conference, many of them found the temptation to ramble on too great.

The meeting consisted of four sessions which contained four invited and 23 contributed papers. In the opening invited presentation Dr. E.A. Davis (Univ. Cambridge) described the electronic and structural properties of amorphous As. This talk was an amplification of his earlier remarks on the same subject at the Cambridge Symposium on the Structure of Non-Crystalline Materials (cf. ONRL Report C-1-77 on this symposium). In addition to discussing the physical model of amorphous As which was built at Cambridge, Davis described the electronic spectra and the density of states for the material. He also described measurements on samples which had been compacted under pressure. Some of these compacted samples exhibited variable range hopping conductivity $\sigma\alpha \exp(BT^{-\frac{1}{4}})$ from which a density of states of $\sim 10^{17}$ cm^{-3} eV^{-1} could be inferred. Davis concluded by mentioning the absence of a linear term in the low-temperature specific heat as measured by W.A. Phillips (Univ. Cambridge) and the optically induced absorption and electron spin resonance (ESR) measurements of S.G. Bishop *et al* (Naval Research Laboratory). A discussion of the optically induced ESR and optical absorption results in other semiconducting materials was presented by P.C. Taylor *et al* (Naval Research Laboratory) in the paper which followed.

Professor P.N. Butcher (Univ. Warwick), in an invited presentation, discussed some recent developments in the transport theory of amorphous semiconductors. He described a molecular model due to D. Emin (Sandia Laboratories) which explains the sign

anomalies observed for the Hall coefficients. In this model the sign of the Hall effects for both electrons and holes depends not only on the local geometry (coordination number of the atoms, for example) but also on the nature and relative orientations of the local orbitals between which the carrier moves (odd- or even-membered rings, for example). Butcher also described recent calculations of the thermo-power in amorphous semiconductors, but the bulk of his talk was concerned with calculations of the prefactor, σ_0, in the exponential expression for the dc conductivity. He considered three illustrative calculations of σ_0: (1) a two-dimensional narrow band with non-degenerate, fixed-range hopping; (2) a three-dimensional narrow band with non-degenerate, fixed-range hopping; and (3) a three-dimensional wide band with variable-range hopping. Analytic expressions for σ_0 were presented for some of these cases in the limits of low- or high-carrier densities. Butcher concluded with a discussion of the conductivity as determined from ac data and commented upon the need for an accurate analytic formula for the conductivity in this regime.

LeComber described the Hall-effect measurements made at Dundee on substitutionally-doped amorphous Si. The essential features of this work were covered by Spear in his presentation at the XIII International Conference of the Physics of Semiconductors in Rome (see ONRL Report C-2-77 of this Conference). The Hall coefficient in both n-type and p-type samples (P-doped and B-doped) is observed to be positive. To explain these results LeComber used the same model which has been suggested to explain the data in undoped amorphous Si. In this model there are two conduction paths, one due to extended states and one due to donor states.

The effects of temperature-dependent band-edge shifts on the thermo-power of amorphous semiconductors were discussed by L. Friedman (Univ. St. Andrews). Thermo-power and photoluminescence (PL) measurements of doped amorphous Si were presented by W. Beyer (Univ. Marburg) and by I.G. Austin (Univ. Sheffield). In undoped amorphous Si there is a PL band at 1.2 eV which shifts to 0.8 eV in the doped material. The PL efficiency is dramatically reduced in the doped samples, and the Sheffield group suggested that this reduction is due to the establishment of internal electric fields which quench the PL. Following these two talks Dr. M.H. Brodsky (IBM, Yorktown Heights) commented that the PL level in doped amorphous Si shifts when the hydrogen is replaced by deuterium in the starting material (silane), and he concludes that the PL must therefore involve Si-H bonds. Professor J. Stuke (Univ. Marburg) disagreed with this conclusion because at Marburg the same PL levels had been found in both amorphous Si prepared from silane and in neutron bombarded amorphous Si (which contains no hydrogen). This was the first in a series of discussions concerning the role of hydrogen in determining the structure and properties of amorphous Si prepared by the decomposition of silane.

D. Weaire and A. MacKinnon (Heriot-Watt Univ.) presented the results of a numerical study of Anderson localization in which they analysed the time-dependence of a randomly specified wave function. Results for both three and four dimensions suggest an Anderson transition at lower degrees of disorder than had previously been supposed. In fact, some analytic theories had predicted no Anderson localization at all in four dimensions.

P.E. Meek (Univ. Cambridge) described the vibrational densities of states of crystalline and amorphous Ge using a bond charge model. He suggested that the ring statistics of the amorphous phase do not influence the phonon spectrum because models employing both even- and odd-membered rings and those employing only even-membered rings yield the same results for the density of phonon states within the framework of this model.

The most interesting and controversial session of the meeting concerned the general topic of defects in solids and, in particular, the role of defects and hydrogen in doped and undoped amorphous Si prepared by glow discharge techniques. The first presentation of this session was an invited paper by Dr. M. Stoneham (AERE, Harwell) on defects in crystalline and amorphous solids. Stoneham enumerated the kinds of defects which can occur in crystalline solids, such as altered coordination, impurities, vacancies, interstitials, and dislocations. He also described briefly some

experimental probes of defects including optical absorption, ESR and photoionization measurements. The main emphasis of the talk concerned a more detailed description of various donors, acceptors, donor-acceptor pairs, vacancies and interstitials in crystals and their analogs, as far as they are known, in amorphous solids. For example, self-trapped holes such as V_k centers exist in both crystalline and amorphous insulators containing halogen atoms, and diffuse acceptors such as B in crystalline Si may also have an analog in doped amorphous Si prepared by the decomposition of silane. Stoneham also mentioned several specific effects which complicate the descriptions of defects in both crystalline and amorphous hosts. These effects include the inadequacy of a one-electron picture, the influence of large lattice distortions, and the presence of both ionic and covalent forces.

Stoneham concluded his presentation with a list of distinctive characteristics of defects in amorphous solids. Certain reactions (such as $2D \rightarrow D^+ + D^-$, as suggested by Mott) may be exothermic in amorphous hosts while they are endothermic in crystalline solids. In an amorphous solid, carriers can be localized to a single atom or bond without polarization or self-trapping. Certain defects such as dislocations or stacking faults are not well defined in amorphous solids. And finally, some processes, such as focused collision sequences, which occur in crystals, are impossible in amorphous solids.

The remaining talks in this session concerned defects in amorphous Si. R.S. Title *et al* (IBM, Yorktown Heights) discussed ESR studies of dangling bonds in hydrogenated, sputtered amorphous Si. They found that, as the number of spins is lowered by carefully varying the hydrogen content of the films, the ESR signal broadens and becomes anisotropic. Title suggested that the narrower Lorentzian line observed at higher concentrations reflected the motion of the spins (motional narrowing), but he interpreted the anisotropic lines in Si and Ge at low concentrations as due to isolated, localized hole centers. Title further speculated that the hole center in question was a simple divacancy as is observed in the crystalline phase. Similar ESR measurements on films with higher spin concentrations were presented by B. Movaghar *et al* (Univ. Marburg). These authors compared variations with temperature and concentration of the ESR linewidth to variations in the electrical conductivity, and suggested a model which correlated these two experimental results.

This session concluded with two presentations on the quantitative determination of the hydrogen content and its bonding configurations in glow-discharge amorphous Si films. M. Cardona *et al* (Max-Planck Institute, Stuttgart, and IBM, Yorktown Heights) compared the infrared absorption from amorphous Si with that observed in various silanes which contain tetrahedrally coordinated silicon atoms bonded to one, two or three hydrogens. From these comparisons Cardona was able to estimate the relative numbers of silicon atoms which were bonded to one, two and three hydrogen atoms in the amorphous films. In a second presentation, M.H. Brodsky *et al* (IBM, Yorktown Heights and Yale Univ.) used several techniques (infrared absorption, Raman scattering, mass spectroscopy and weighing) to determine the amount of hydrogen in a series of Si films which were made by sputtering and by decomposing silane. These authors found that the glow discharge films contained at least 20 at.% of hydrogen all of which was bonded to the network, although films sputtered in argon and hydrogen could be made with considerably less hydrogen content. At this point one might question the accuracy of calling the glow-discharge films "amorphous silicon" and perhaps suggest that "silicon-hydrogen alloys" might be a more appropriate term. Regardless of what they are called, substantial interest in these materials by the large industrial laboratories, in particular IBM and RCA, is destined to continue until their potential usefulness for such applications as solar cells and other large-area devices has been carefully evaluated.

The final session of the meeting covered the topic of switching in amorphous semiconductors. The interest in this session was not in the performance of these switches, which have not been able to break the hold of silicon technology on the commercial market, but rather in some new insights into how the switching process works.

In an invited talk, Professor D. Adler (MIT) described some recent measurements on crystalline Si-chalcogenide glass heterojunctions from which the filament diameter in the glass during the "on" state can be estimated. Filament radii, r, ranged from 1 to 20 microns for currents below 200 mA. The current was observed to vary as r^2 which implies a constant conductivity in the "on" state. Adler estimated a temperature rise of not more than 60°C in the filament for currents less than about 200 mA and concluded from this estimate that the switching process in the threshold switches was electronic and not thermal in origin. Four years ago such a definitive conclusion would have been heralded with a great fanfare, but at this meeting the conclusion seemed almost anticlimactic.

Adler described the recovery from the "on" state in the switch as a shrinkage of the filament size at constant current density followed by a rapid fall-off in the number of carriers as the radius approaches zero. Speculation concerning the causes of switching concluded Adler's presentation. He suggested that intially (in the "off" state) the conduction is p-type and the highest field occurs near the anode. In time this high-field region propagates from the anode to the cathode, at which point electrons can then be injected. After this time, traps can be filled, and eventually the on-state current consists of equal contributions from electrons and holes.

After Adler's talk, Professor N.F. Mott (Univ. Cambridge) gave a short presentation which was officially billed on the program as "Comments on Professor Adler's Paper". In his remarks, Mott speculated that within the current channel the electronic properties might resemble those of an electron-hole liquid such as occurs in crystalline Si at low temperatures for high optical pumping power. This speculation was motivated by the fact that the electron and hole mobilities in the on-state (10 $cm^2 V^{-1} sec^{-1}$) were similar to the values one would expect near a mobility edge. (P. Craig Taylor, NRL, Washington, DC, on sabbatical at Heriot-Watt Univ., Edinburgh)

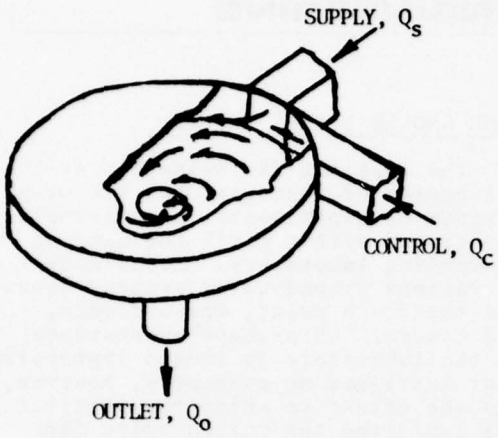
ENGINEERING

SEHR GROSSE VORTEX VALVEN

The Institut für Wasserbau at the University of Stuttgart has the usual variety of experimental paraphernalia associated with a civil engineering hydraulics laboratory. Scale-models of various ground-water systems abound, and the fresh paint, waxed floors, and general "ship-shape" appearance of the laboratory is indeed impressive. What intrigued me even more, however, was the extent to which the Institut has exploited the vortex valve for large-scale commercial applications.

The Head of the Institut is Prof. J. Giesecke whose enthusiasm has been mentioned in an earlier report (ESN 30-2:66). This note is a follow-up on one of the sources of that enthusiasm, which is largely the work of Dr. H. Brombach and Messrs. J. Ruppert and H. Neumayer. Under Brombach's leadership, and with the help of several research students, this group has conducted a comprehensive series of investigations of the behavior of several different configurations of vortex valves. The work is noteworthy in two respects: (1) it is an adaptation by civil engineers of a technology that was developed in other engineering fields, and (2) this adaptation has resulted in a significant physical enlargement of fluidic devices, especially vortex valves, for application to the relatively massive flows encountered in civil engineering practice. Two of these applications are described here.

The basic radial vortex valve configuration is sketched on the following page:



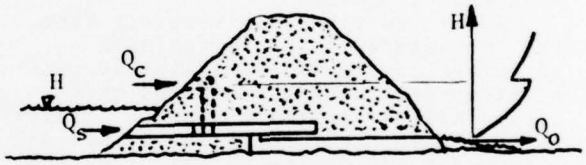
The interaction of the control flow Q_c with the supply flow Q_s is such that a strong swirling motion is established within the valve. Withdrawal of the combined flow from an axial outlet results in large accelerations from inlet to outlet, and the consequent high flow velocities, together with the lengthened flow path, result in high frictional losses relative to the flow when there is no swirl (i.e., no control flow). Thus, the influence of the control flow is reflected at the outlet (usually in a nonlinear way), and the device has many of the properties of an amplifier. By means of various permutations on this configuration, several control and sensing functions can be performed by the vortex amplifier (there is also an axial-flow version), and it has often been a major component in fluidic controllers in which air is the working medium and smallness is a virtuous but elusive goal. At Stuttgart, however, the flow control application is for water systems, and many of the vortex valves appear huge to the fluidics engineer: one experimental valve is 2 m in diameter.

Both of the applications described here involve installations in which the supply and control pressure heads are equal. The goal is to control the outlet flow and a measure of success is given by the control factor:

$$S = (Q_o - Q_{o,c})/Q_o$$

where Q_o and $Q_{o,c}$ are the outlet flows with the control port closed and open, respectively (e.g., S would equal 1 if the control flow could completely shut off the valve--an extreme situation that is unattainable by fluidic means). Radial vortex valves designed and tested at the Institut are capable of control factors of up to about 0.6; that is, with equal supply and control pressures, an outlet flow of 40% of the unthrottled flow is obtained. Provided the pressure heads are equal, these results are relatively independent of their magnitude.

The vortex valve, which has no moving parts, is seen as an ideal device for controlling the reservoir level and rate of overflow for water detention basins used in flood-control systems. The basic self-actuating concept is sketched below:



By tailoring the valve design and using parallel valves with different control-port elevations, considerable flexibility is obtainable in the basin outflow characteristics. If required, the outflow can be maintained at a relatively constant value over a wide range of basin depths. An application currently under study at the Institut is the use of vortex valves in the Täferrot basin, just east of Heidelberg, which holds back the waters of the Lein rivulet, a tributary of the Neckar River. This design, which is based upon extensive scaling studies, involves three valves in parallel, each 19 m in diameter and 2 m in height. The valves would maintain a controlled maximum outlet flow of 33.2 m^3/s over a basin level from 408.45 m (where the first control port is filled) to 412 m (where the third valve comes into play) and a reduced rate of flow increasing by about 1.7 m^3/s with each meter of reservoir depth thereafter. Using hydrographic data for the Täferrot basin, Brombach has done some calculations to show that the tailoring of the outflow by vortex valves can lead to a 13% reduction in required basin volume.

The chief drawback of the vortex valve in the flood control application is its sheer size--a large supply-to-outlet diameter ratio is essential

to the principle of its operation. In spite of this, the Institut has won a recent competitive bid for the design of a major system to go into a flood-control project near Stuttgart. There is still political inertia (the funds, as I understand it, are being delayed), but Giesecke and Brombach are optimistic that the vortex valve will soon play a role in what promises to be a major departure from traditional reservoir designs.

One special virtue of the radial vortex valve is its self-cleaning behavior, and this has led to another application of a somewhat different nature. If a solid body finds its way into the vortex chamber, the momentary effect is to increase the flow, rather than block it. The cause of this unusual but fortunate behavior is the temporary breakdown of the vortex motion. In fact, an elongated body will be oriented by the flow, so that its long-axis is aligned with the outlet stream, and it will get through even though its major dimension is greater than the outlet diameter. The result? Control of sewage outflow, of course. The Institut now markets and produces a line of sewage control valves of remarkably simple design. These have been tested and proven in the field, and 16 have been ordered by various German sewage disposal plants. The radial vortex valves are about a meter in diameter and cost DM 3000 (about $1,250)--less than half the price of the commercial alternative which doesn't work nearly as well.

The research at the Institut has contributed significant insights into the flows associated with all sorts of vortex-valve configurations. A recent development has been the conical vortex valve in which the losses in the flow, without control flow, are greatly reduced. As a result, the control flow is able to reduce the total outlet flow by about 80%--a new high in vortex-valve throttling ability. The most advanced experimental techniques have been used, including laser-Doppler velocimetry and some very high-quality flow visualization methods. It was most interesting and gratifying to see these results leading to some new applications that are well suited to the special features of the vortex valve. (Robert H. Nunn)

THE FLUID MECHANICS RESEARCH INSTITUTE AT ESSEX

A unique program in fluid mechanics research is being pursued at the Fluid Mechanics Research Institute (FMRI) of the University of Essex. The Institute, under the direction of the distinguished mathematician-fluid dynamicist Prof. T. Brooke Benjamin, was founded in 1970. Funding for the Institute is provided by the Science Research Council (SRC).

The staff of the FMRI consists of five faculty and research workers of varying seniority, five PhD research students, three MSc students, and two visitors on sabbatical leave from their universities. Benjamin explained that the Institute is short-staffed because of the mobility of good people, but expressed satisfaction with the quality of foreign visitors.

The general philosophy of the FMRI is, in Benjamin's words, "to combine pure mathematics, such as topology and functional analysis as applied to non-linear partial differential equations, with well-conceived and executed experiments in an attack on problems in fluid dynamics". As an example of other problems of interest to the FMRI, Benjamin cited an analysis and experiment on a non-fluid dynamical problem of mode bifurcation in the finite amplitude forced oscillation of a continuous spherical pendulum.

The point of view with respect to fluid mechanics, according to Benjamin, is to consider the full Navier-Stokes equation with proper rather than idealized boundary conditions and to compare the theoretical results with carefully obtained experimental data. In the past, idealized theoretical results have been used as a guide in obtaining experimental data from a physical situation that did not precisely correspond to the mathematical model, so much so that data points were found where they did not actually exist. An example of the foregoing is the problem of classic Couette flow (flow in the annulus between concentric cylinders rotating at different angular velocities), which was investigated both theoretically and experimentally by G.I. Taylor many years ago. Taylor's experiment involved cylinders of finite length whereas his theory was developed for

infinite cylinders. The experiment indicated a cellular disturbance structure similar in appearance to a regularly, axially-spaced set of smoke rings concentric with the axis of the cylinders. The theory confirmed this structure when a dimensionless parameter, the Taylor number, exceeded a critical value. Benjamin pointed out that the cellular disturbance observed experimentally by Taylor is not an instability in the ordinary sense, but a secondary flow; it exists at all values of the Taylor number, not just for the Taylor numbers exceeding the critical value of the theory. In a finite length Couette-flow experiment, the boundary layers at the ends provide a return for secondary flow and hence serve to excite the Taylor disturbance. Thus, the experiment models the response of the annular fluid to excitation at the ends while the theory for infinite cylinders concerns a self-excited disturbance. The same observations and comments apply to Bénard convection (natural convection) between two horizontal planes of different temperature. The theory is based upon the assumption of infinite planes, whereas the experiments must, of course, refer to finite planes. Benjamin pointed out how topological considerations indicated a hysteresis in switching between disturbance modes in Couette and Bénard flow analogous to the catastrophy theory of bifurcation and changeover.

Also of current interest in the Institute is the study of wave evolution problems, specifically surface water waves. Long solitary waves (called "solitons") and the breakup of large single waves into a series of solitons are being studied. It is found, for instance, that the usual mathematical model for dispersive, finite amplitude waves (the Korteveg-de Vries equation) does not adequately describe the phenomenon.

In the laboratory, small-scale experiments concerning waves in shallow water are in progress. Dr. John C. Scott, an experimental physicist performing the work, explained the difficulties associated with researching wave phenomena in pure water without a film--it seems that even when using distilled water in a "clean" environment, a monomolecular film soon accumulates on the surface and alters the propagation characteristics of waves. Data for filmless surface waves must therefore be obtained quickly. Since many films are inextensible, or not readily extensible, the motion of the water beneath the film causes a boundary layer beneath the film where large shearing rates exist in the fluid, hence the waves are generally strongly damped. Also, because the film contributes a stiffness to the system, the velocity of propagation of the waves is increased. The effects of contaminants and surfactants (polymers) are being studied under a grant from the Natural Environment Research Council (NERC). There is also a large set-up in the laboratory for studying waves on beaches and the diffraction and distortion of waves around islands.

In a stagnant film experiment, water flowing under the leading edge of the stagnant film could be seen to cause a ripple there. In a demonstration, the addition of a drop of salad oil to the film caused the leading edge to advance, whereas the addition of detergent or soap destroyed the film and caused its leading edge to recede.

A number of interesting non-standard experiments involving rotating flows was demonstrated. One experiment dealt with the flow inside a liquid-filled cylinder rotating about its axis. A rod of semi-circular cross section with a diameter equal to the inner diameter of the cylinder was held stationary inside the cylinder as it rotated. Taylor-like disturbances appeared inside the cylinder. The same phenomenon could be observed in a rotating horizontal cylinder partially filled with a liquid; the free surface, which was actually coated with a film, played the same role as the semi-circular cylindrical rod previously described. Another experiment concerned a long, liquid-filled cylinder with one closed end; the open end of the cylinder was immersed in a fluid-filled tank and the cylinder (not the tank) rotated about its axis. The closed end of the tube imparted rigid-body rotation to the liquid while the flow at the open end corresponded approximately to a non-rotational state. The tangential flow field in the tube induced an axially-symmetric, similarity flow whose magnitude was greatest at the tube mouth and zero at the tube end.

In another experiment, a stratified fluid in a tank was selectively withdrawn from a horizontal slot in one end. The induced flow in the

tank was similar to a wake velocity distribution (flow distribution behind an object being moved through a fluid) whose magnitude increased as the slot was approached. In addition there was a downward flow above the withdrawal level which filled in the volume withdrawn. The study is of interest where levels of a given salinity or temperature in a stratified body of water are to be selectively withdrawn.

A study of turbulent Poiseuille flow in a capillary tube at Reynolds numbers of the order of 30,000 was concerned with the drag reducing properties of polymer additives and the degradation or chain breaking of the additives under high deformation rates. The experiment seemed primarily designed to degrade the polymer additive because of the high shearing rates at even small Reynolds numbers. The drag reduction properties of the additive are probably not representative of the same Reynolds number flow in large-diameter tubes.

The Institute impressed me as a place with a track-record for quality results and where fluid mechanics is being viewed in a refreshingly non-standard way. (Martin Lessen)

APPLIED FLOW RESEARCH AT THE INSTITUT FUR TECHNISCHE STROMUNGSLEHRE IN DARMSTADT

Research at the Institut für Technische Strömungslehre at the Technische Hochschule Darmstadt is focused on applied fluid dynamics research. The director, Prof. Dr. Ingr. J.H. Spurk, was formerly associated with our Aberdeen Proving Grounds for a ten-year period from 1962-1972. As he was away during my visit, I was conducted around by Dr. Ingr. Norbert Zloch.

Zloch was formerly a student of Prof. Dr. Ernest Becker of the Institut für Mechanik at Darmstadt, and his present research, which is concerned with shock wave attenuation in tubes, is a natural outgrowth of his earlier work with Becker. The study concerns the effect that drag on the flow behind a shock wave has on the strength of the shock. As the shock wave progresses through the tube, boundary layers develop on the tube wall behind the shock, and finally there is fully developed turbulent Poiseuille flow. The resulting drag and slowing down of the flow behind the shock wave decreases the shock intensity thereby attenuating the shock. For the effect to be optimal it is necessary for the fully developed Poiseuille flow to be turbulent; a laminar flow would not develop sufficient drag. As the shock wave travels along the tube, it attenuates and finally becomes a sound or Mach wave. The general idea also works for bundles of fine tubes and granular beds, but as the Reynolds number (based on the tube diameter or intergranular spacing) gets smaller, the flow approaches the laminar state more closely and the effect is diminished. The research has important application for the ventilation of air raid and blast shelters.

Additional activity in gas dynamics is concerned with combustion and chemical reactions in boundary layers and detonation waves. The boundary layer work, both theoretical and experimental, is involved with hypersonic flows. Some combustion and detonation research is also conducted in a square cross-section, glass-walled single cylinder internal combustion engine such that optical measurements can be made of the ongoing processes.

A very interesting research project in biomechanics is in progress. The Institut is developing a prosthesis to replace part of the ureter and the entire bladder in humans. The upper part of the ureter (adjacent to the kidney) is retained and a plastic lower ureter integral with a plastic shell bladder is inserted to replace the natural structures. The bladder shell contains a collapsible sac inner lining which is continuous with the artificial ureter and is also connected to the urethra. A check valve in the artificial ureter prevents retrograde flow to the kidney and also overpressure on the kidney. An additional check valve is placed between the urethra and bladder sac. The bladder sac can be collapsed inside the plastic shell bladder when fluid from a piston ejector (outside the body) is introduced between the bladder shell and the sac. Of course, this arrangement necessitates a permanent tubular connection through the abdominal wall. The philosophy behind retention of the upper portion of the natural ureter is that it will continue peristaltically pumping the urine into the bladder. Since the bladder

is generally at a higher pressure than the kidney, this pumping action is necessary; it seems that sufficient pumping action is obtained from half of the natural ureter. The artificial portion of the ureter diverges to form a diffusor thus allowing the peristaltic action of the natural upper portion to pump across a maximal pressure rise. At the time of my visit, twelve dogs had been operated on, half with bladder-partial ureter replacement and the others with just the ureter replacement. The longest surviving dog lasted seven weeks with no effort being made to use body-compatible materials.

The aeroelastic behavior of turbine cascades and rotors, and aeroelastic instabilities of the blading and the labyrinth seals associated with rotor shaft vibrations are being studied. It was found theoretically and confirmed experimentally, that only with an even number of blades in a cascade can there be an azimuthally periodic blade vibration. Also, interaction of asymmetric seal leakage with the rotor system can induce shaft vibrations.

An investigation of flow fields about high speed trains in tunnels is in progress. The effect of varying the ratio of the cross-sectional area of the train to that of the tunnel is studied at train Mach numbers of 0.3 to 0.4. When the train enters the tunnel, there is naturally a shock or compression wave that develops and precedes the train at a much higher velocity. The research is carried out by using a piston driver to accelerate a rod (shaped as a train model) to the test velocity. The rod then flies freely at a specific position through a glass-walled channel so that the flow field about the model can be studied interferometrically.

The Institut für Technische Strömungslehre is applying its expertise to defining and solving real problems. Since real problems are generally "dirtier" than conveniently-defined hypothetical ones, and the results more useful, this dedication is to be commended. (Martin Lessen)

ONRL REPORTS

See the back of this issue for a list of current abstracts.

ENVIRONMENTAL SCIENCES

THE INSTITUTE FOR METEOROLOGY AND GEOPHYSICS, INNSBRUCK

The Institute for Meteorology and Geophysics at the University of Innsbruck is housed in two nearby locations on the outskirts of the town at the foot of an impressive mountain range. It was founded in 1891 and at that time the accumulation of meteorological data began. The history of the Institute is interesting, for it is associated with many famous men, some of whom reached their fame in fields other than meteorology. For example, V. Hess discovered cosmic rays while at this Institute. In the 1900s H. Ficker carried out synoptic studies of foehn situations, some of which were made in balloon flights which took him quite some distance from Innsbruck. In 1924 Albert Defant became Professor of Cosmic Physics, and after leaving for the University of Berlin in 1927 he returned to the Institute in 1946; he retired in 1956 and lived in Innsbruck the remainder of his life. Also, H. Ertel, a name well known in dynamic meteorology, was a member of the Institute during the WWII years.

Research at the Institute dwells on the following subjects; glaciology, polar boundary layer, snow-ice-air interface, radiation studies in the presence of snow and ice, lee-waves, foehn, internal gravity waves, effect of mountains on cyclogenesis, as well as synoptic meteorology studies.

Prof. H. Pichler, Director of the Institute, came to Innsbruck in 1971 after nine years as Prof. H. Reuter's assistant at the University of Vienna. Having also spent six years at the Austrian Weather Bureau, he has done much to bring dynamic meteorology to the Institute. He has four assistants: Drs. I. Vergeiner, M. Kuhn, R. Steinacker (whom I met), while the fourth is on leave at Fort Collins University in Colorado. Dr. H. Rott, although not having the official title of assistant (for there are only four available slots), has nevertheless the same stature in the Institute. There are about twenty students

associated with the Institute, five or six of whom are graduate students. The senior professor associated with the Institute, Professor H. Hoinkes, died in 1972. He was instrumental in starting research in glaciology. His position will probably be filled by Prof. H. Bolle from Switzerland.

Vergeiner has spent about five years in the US at Fort Collins, at NCAR (National Center for Atmospheric Research) in Boulder and at the University of Illinois. He has published a number of papers on lee-waves which are internal gravity waves generated by the passage of an air stream over mountains. The present status in this field is discussed and summarized in one of his publications (which will probably not receive a wide enough exposure), *Rivista Italiana di Geofisica e Scienze Affini* I, pp. 15-31 (1975). In this paper, which is in English, he considers a non-hydrostatic, adiabatic and frictionless flow and assumes that the rotation of the earth can be neglected. His model also takes care of absorbing the wave energy that propagates upwards in order to model a realistic upper boundary condition. Because he has access to only a small computer (CDC 3300), he must use Fourier decomposition in the horizontal plane; this requires the lateral boundary conditions to be periodic. The model is tested on a mountain of 10 km diameter with a 2 km height. Some of his findings are: Vertical wind shear enhances strong downslope winds; the hydrostatic condition is not essential if one is interested in these downslope winds which are caused by the bunching of streamlines on the lee of the mountain, resulting from the requirement that energy propagates upwards with height. A more realistic topography representing the topographic features found around Innsbruck was also used. The model was extended to include the earth's rotation, and eight selected model radiosonde ascents were used. The solutions are discussed in detail in a recent paper in German, "Föhn-und Leewellenströmung in einem dreidimensionalen numerischen Modell", *Ber. Nat. med. Ver Innsbruck* 63, pp. 11-56 (1976).

Kuhn is interested in field programs dealing with snow-ice-air interfaces, polar planetary boundary layer and radiation studies. He spent six months with the University of Washington's group working at the Arctic Research Laboratory, Point Barrow, Alaska (sponsored by ONR) and on the floating islands Alice II, III; he also spent fifteen months (1966-68) at Plateau Station Antarctica (80°S, 40°E) near the center and top of the Antarctic Continent (+3600 m). He was carrying out a field study program using a 32-m tower instrumented on ten levels to obtain meteorological information in the boundary layer. This work was partly sponsored by US agencies (ESSA, NSF) and the University of Melbourne. In 1968-69 he spent another four months at the South Pole Station carrying out studies on radiation over ice. The station, located exactly at the South Pole, proves to be very convenient because of the constant solar elevation (this is possible only at the South Pole since the North Pole is over ice sheets that undergo slow drifts). The radiative studies dealt with the measured distribution of reflected intensity and how it is affected by the grain size of snow and by the large-scale topographic features like snow waves or dunes. According to Kuhn, research in optical properties of snow will probably receive the most active development within the next five years. When dealing with radiative problems, this knowledge is needed if one wants to apply the correct boundary conditions over snow. He has submitted a proposal to NSF to study the spectroscopy of snow and investigate reflection at visible and near infrared frequencies.

Kuhn is also collaborating with Rott on a project supported by UNESCO ("Man and Biosphere") in which data on velocity, temperature and humidity are being collected at three altitudes above ground level and radiative budgets are being measured. These measurements are being made to understand the behavior of Alpine grassland and to determine how man has interfered with ecology by establishing recreational centers where Alpine grazing was originally found. They are also trying to determine whether there is a relation between removal of grassland and avalanches. As far as future work is concerned, Kuhn will study the freshwater run-off from glaciers into small Alpine lakes and will try to determine the level at which this run-off water settles and whether there is a circulation in these small

lakes. Nutrients and O_2 found in these run-offs strongly affect the animal life in lakes, and limnologists at Innsbruck are interested in the biological restoration of several Alpine lakes which are being suffocated by algae growth that absorbs most of the oxygen.

Steinacker is interested in cyclogenesis and with Pichler, has been trying to obtain more quantified measures which will help in forecasting. By computing some non-dimensional numbers from synoptic weather charts, he is able to infer the intensity of cyclogenesis that will evolve. Rott is primarily interested in radiation, satellite meteorology and in meteorological instruments. He hopes to have an active interaction with Bolle who is also interested in similar areas.

Thus, although small, this tightly knit group offers some original and quality work in a number of problems in meteorology. (A. Barcilon)

THE INSTITUTE OF THEORETICAL METEOROLOGY IN MUNICH

At the Institute of Theoretical Meteorology, University of Munich, research in dynamic meteorology is focused on three main themes dealing with numerical modeling: dynamical climatology, the study of forced long atmospheric waves, and the role of mountains in cyclogenesis. The moving force behind most of this research is Dr. J. Egger, who is supported by three or four assistants, all working in models of dynamical climatology. Professor G. Holland held the Chair of Theoretical Meteorology and was the director of the Institute until his death a few years ago and Egger is now temporarily filling that position until a suitable replacement is found. (Professor H. Fortak of the Free University of Berlin was considered, but he declined the position.)

Dynamical climatology is an area of research which is still in its infancy. The object of this work consists in establishing models that can, with some reliability, predict climatic features on various time scales. These time scales range from a few weeks to several years, but currently, seasonal or yearly changes are probably the upper limits that one can hope to reach with these models. For obvious reasons such models are numerical in nature and can be of various kinds. The more detailed ones, which can be used on the lower end of the predictive time scale, are models of the general circulation of the atmosphere, similar to those used for numerical weather prediction. They describe complex feedback mechanisms that exist in that very complicated system which is composed of the earth's atmosphere, the oceans, the cryosphere and the earth's vegetation. Within this system solar energy is received unevenly at various latitudes, stored in the form of latent heat and redistributed by atmospheric and oceanic motions which are constrained by the earth's rotation. For the smaller time scales, the oceans, cryosphere etc., are subsystems which react on much longer time scales and can therefore be considered "frozen", i.e., they do not have time to adjust to the forcings. Atmospheric motions occur on much shorter time scales. If we limit our attention to the larger scales of motions, we find that we are dealing with eddies that have a considerable horizontal extent. Some of these eddies are transient and result from an instability of a zonal current. Others are more permanent and are due to the presence of topography or heat sources caused by the longitudinal anisotropy created by land and ocean masses.

Other types of climatological models, the statistical dynamical models (SDM), attempt to parameterize these large-scale transient eddies as a kind of turbulence. The advantage of such a procedure lies in achieving prediction on longer time scales and in more economical computational performances. Their disadvantage lies in a difficulty common to all problems dealing with turbulent flow--the problem of closure: One must truncate the system of equations which describes these turbulent flows and relate the eddy statistics to the mean flow field, i.e., to the flow field which has undergone some suitable averaging process. At present, there does not seem to be a satisfactory theory for closure, and attempts to overcome this difficulty have been focused on three approaches: (a) they have tied the eddy fluxes (i.e., the amount of heat and momentum transported by these eddies) to the

mean flow by means of diffusive-like equations which mimic similar equations found in laminar flows; (b) they have used theoretical results of linearized instability theories connected with the incipient formation of these eddies to extract some spatial dependence for their structure; using these estimates and considerations based upon energetics, they have provided an expression which ties eddy fluxes to the mean-flow properties; and (c) they have established prognostic (i.e., time-dependent) equations for the eddy statistics and delayed the closure problem at higher order by considering a larger set of truncated equations.

The work of Egger and his assistants falls in category (c) described above. In a steady-state, zonally averaged two-layer model Egger assumes that all the eddy variables are random functions having a normal probability distribution. This assumption is tantamount to postulating a specific closure relationship and has not been without its critics. Yet, Egger feels that the model is performing satisfactorily: Some of its predictions, obtained when the drag coefficient was halved, compare rather well with similar and more sophisticated experiments performed by Dr. J. Smagorinsky in the US. For more details the reader is referred to Egger's recent paper: *Tellus* XXVII (4), 325 (1975). Work in this area continues; Egger and his assistants, Drs. W. Metz and K.P. Hoinka, are considering three-dimensional rather simplified SDMs. Friction, non-adiabatic effects, orography and thermal forcing are included in the equations. Using numerical experiments their goal is to assess the capabilities of these SDMs for simulating climate. The statistics of the SDM are compared with those of an explicit model. Some of these SDMs have predictive equations for the first- and second-order moments. This work which appeared as a technical report in German, is being rewritten in English and will be submitted to a technical journal. Because of the very simple structure of these models, their comparison with the atmosphere should be done with caution.

Continental land masses, mountains, heat sources such as the sea-surface temperature anomalies, and latent-heat released in large areas where precipitation occurs introduce longitudinal variations in the atmosphere which could force standing atmospheric waves of long wavelength. Egger constructed a simple, linear, two-layer numerical model which seems to give good results when the data from average January conditions of the Northern Hemisphere are used. The model does not perform as well when the averaged July conditions are used. Egger believes that the paucity of good data in addition to the reduced North-South temperature contrast which prevails in the summertime might be responsible for this lack of accuracy. Most of this work is reported in *Mon. Weather Rev.* 104 (4), 351 (1975). Egger plans to couple this linearized three-dimensional model with the steady-state, zonally averaged SDM previously discussed. The SDM will provide the basic flow for the linearized model on which longitudinal forcing will be introduced.

Cyclogenesis by mountains is a field of special interest nowadays since the Global Atmospheric Research Program (GARP) is about to create a subprogram which is to be devoted to this aspect of atmospheric flows. Egger began looking at some of these problems some seven years ago. In a series of numerical experiments in which he considered the Alps and the massif of Greenland, he showed that in some cases, mountains (Alps) cannot be smoothed on distances of the order of the grid spacing (300-400 km) found in most general circulation models. Rather, their effect is properly accounted for only if they are included as knife-edge barriers. According to Egger, as a cold front (i.e., a discontinuity between adjacent air masses) approaches these barriers, its travel is stopped at low levels while the warm tongue of air aloft crosses the mountain. This air is responsible for the creation of a low-pressure center in the lee of the mountain. This explains the frequent formation of cyclones that occurs in the lee of the Alps in the Gulf of Genoa. The reader is referred to Egger's article for more details: *Tellus* XXIV (4), 324 (1972).

When I asked Egger if he felt his group to be somewhat isolated, his reaction was somewhat surprising: "At least we are not disturbed by a constant flux of visitors." Thus,

although physically somewhat isolated, this small group under Egger's leadership has been able to remain very much within the mainstream of dynamical meteorology. (A. Barcilon)

THE UK METEOROLOGICAL OFFICE COLLEGE

The UK Meteorological Office (Met. Office) is the largest institution in the UK dealing with research (and applications) in meteorology. In fact, there are very few universities in this country which offer formal training in this field, especially at the undergraduate level. To fill its research positions the Met. Office draws, in part, upon young graduates who have completed honours degrees in mathematics and/or physics and, for the most part, have not had previous knowledge or training in the field of meteorology. Since the beginning of WWII, the Met. Office has relied upon its own College to provide intensive professional training for meteorological staff at various levels. The courses offered are not reserved uniquely for Met. Office employees, but are also open to foreign meteorological services. Foreign students are either self-supported or are sponsored by the World Meteorological Organization or their own government. The courses are of various standards, some being designed for the newcomer to meteorology and presented either at very advanced or elementary levels, depending on the background of the student; others are for the meteorologist with years of experience in the area of forecasting and synoptic meteorology. The primary purpose of each course is to equip the student for the practical duties that await him at the Met. Office. Met. Office leaflet No. 4 describes the content of all the courses, and there is also a list of courses being offered citing tuition charges, both of which may be obtained from the College by writing to Meteorological Office College, Shinfield Park, Reading RG2 9AU, UK.

The campus is quite adequate and roomy and is located some three miles from Reading, which itself is only some fifteen miles away from the headquarters located in Bracknell. It is interesting to note that the new buildings of the European Center for Medium Range Weather Forecasting (see ESN 30-1:42) are to be located on campus. The college is designed to accommodate on a full-board basis about 100 students, and there are about 17 full-time instructors.

Another feature peculiar to the Met. Office is that of rotating a person through various job positions, the change from one job to another taking place every three or four years. Mr. S. Cornford, the Principal of the College, and Dr. H. Cattle are newcomers to the field of education; Cattle was doing research on data assimilation and is now in charge of the Scientific Officers' (SO) course. The courses offered can be divided into three levels or streams; stream 1 contains the most difficult studies while stream 3 is for assistants, technicians, and observers working in weather forecasting or related disciplines. The Scientific Officers' course starts at the end of September and runs for 26 consecutive weeks ending sometime at the beginning of March. It is open to first- or upper second-class honours students in mathematics or physics. After being accepted by the Met. Office, a student entering that course spends the first week on the job at headquarters, in Bracknell, where he takes care of usual formalities resulting from starting on a new job. He then reports to the College and is expected to live on campus; however, since the College is quite close to Reading and Bracknell where most of the Met. Office staff reside, this rule is often broken. For the last few years the number of students in the SO course has been around 20, although according to Cornford, there was once as few as 4 enrolled. The number of students in this course is a function of job availability and fluctuates with the UK economy and the internal composition of the Met. Office.

Once the student reports to the College, he has nine weeks of formal classroom lectures in the areas of physical, dynamical and synoptic meteorology as well as laboratory work followed by three weeks of current weather predictions using "old methods", i.e., not relying upon computer-generated weather forecast maps. Teams of four to five students are formed consisting of a "senior forecaster", "a deputy", a "local weatherman" and a "supervisor". The duties

associated with the titles are rotated everyday, and each team prepares 24-hour and 3-day forecasts which are presented and discussed each late afternoon of this three-week period. By now the applied mathematician and the physicist enrolled in the course have enough know-how to prepare their own forecasts, and for the four weeks that follow they are sent to small out-stations in the UK. These can be small inland airports or maritime weather stations; students work under the supervision of a professional forecaster and apply the knowledge they have acquired. They return to the College for another six weeks. In the first two they relate their impressions and undergo intensive interviewing by the five Deputy Directors of the Met. Office to determine where their talents can best be used. They also have lectures on statistics if they did not have that subject at University and on the administrative structures of the Office.

In the last four weeks, the mornings are spent attending sets of advanced lectures, about 40 in all, given by well-known specialists from the Met. Office or from universities; these are designed to bring the students up to date in the topics selected. This same student body will return for similar lectures (given on different topics) for two consecutive years so that, in principle, after three years it will have been exposed to the most up-to-date information over a very wide range of meteorological research. In the afternoons of these four weeks, the student undertakes an individual project. He is discouraged from choosing a topic in which he might have been familiar before arriving at the College; at the end of this period he presents his findings in an informal seminar. These last six weeks, forming the second part of the course, are optional to overseas students but are compulsory to Met. Office staff. The class being small and there being four to five instructors enables the faculty to follow each student's performance closely and gauge his progress. The feedback between students and instructors is informal--marks are used for internal purposes only and are not given when a student evaluation is requested. Cornford was amazed to discover how accurate these evaluations have been in the past.

Mr. L. Dent is in charge of the forecasting courses which fall into stream-2 category. There are several courses, offered at different levels, but all are characterized by rather short classroom stays followed by longer periods spent in the field. For example, to enroll in the Initial Forecasting course one must have had the mathematics and physics equivalent to one year's study at a university for a science degree. The course requires 18 weeks of classroom studies covering physical, dynamical, synoptic and practical meteorology. The student then spends two to three months in the field receiving further training and returns to his job and works for an outstation as a forecaster for another three years. These stations may be either civil or military aviation centers or weather stations. At the end of that time if he wants to further his career, a "Selected Board" reviews his case. If found satisfactory, he returns to the College for the Advanced Forecasting course which lasts seven weeks followed by another three months field training. At the completion of this (usually about four years since he started), he is promoted to a higher position within the Met. Office.

Mr. F. Underdown is in charge of stream-3 courses which deal mainly with observers, technicians, etc., and are designed to train people to assist those involved in weather forecasting. For example, industry (especially the oil industry) is aware of the importance of accurate forecasts. Therefore, some of the personnel working on oil rigs might be sent to the College to attend Meteorological Observers' courses. Underdown feels that these courses do much to motivate a man, say a technician, and make him more aware of the problems and needs of forecasting.

In conclusion, this highly condensed method of teaching meteorology at all levels, especially the graduate level, seems to work. Compared with other European countries, the UK is probably the leader in the fields of research in various branches of meteorology. (A. Barcilon)

GENERAL

UK REACTOR DECISIONS?

In July 1975 the continuing debate and reaction to nuclear power development in Europe was the subject of an article by Schneider in these pages entitled "Something Wrong with Nuclear Energy--European Impressions" (ESN 29-7:308). In what follows we up-date this earlier account in terms of the UK, necessarily retreading some old ground, including the 1974 Government decision favoring the steam generating heavy water reactor (SGHWR) against other reactor possibilities for the next power installations. We pursue this through the activities of the House of Commons Select Committee on Science and Technology and of a special study group established by the UK Atomic Energy Authority (UKAEA) to study the integrity of pressurized water reactors (PWR).

Clearly, one of the most contentious issues of the moment is the development of nuclear power. The debate surrounding it is particularly vociferous in the UK where, in addition to the natural topics of operational safety, radioactive disposal, etc., it is complicated by many other pressing factors. The British economy is depressed; expenditures for nuclear or any development must be weighed with utmost care. There is a substantial balance-of-payments problem; exporting nuclear reactors, nuclear components, and nuclear technology is a fond hope, if not a definite requisite. Britain currently has an over-capacity for electric power generation; but estimates of future power station needs and of what type have varied substantially, complicated as they are by imprecise long-term estimates of the availability in quantity and time of fossil fuels. To react (or over-react) by dismantling the nuclear development program could remove Britain from the nuclear market now and perhaps forever. Britain's capacity, at best, would appear to allow for the development of only one major reactor system at a time; yet nuclear forecasting is notably imperfect. There is no firm vision of which systems will be adopted by the nations that will import nuclear reactors, or when. Overlaying all of this has been the apparently ever increasing cost, financial or otherwise, of each technological debacle.

How does a nation, faced with these constraints and difficulties, proceed with the decision-making process? Unfortunately, the history of this decision-making to date is not encouraging. It is perhaps best followed through the activities and reports of the House of Commons Select Committee on Science and Technology, which has moved in at crucial times on the continuing debate. The Committee's report to the House of Commons in Jan '74 on "The Choice of a Reactor System" came at a time of particularly heavy controversial debate and discussion, and was followed in July by the Secretary of State for Energy's announcement that "The Government, after taking the advice of the Nuclear Power Advisory Board, (NPAB) had decided that the Electricity Boards should adopt the SGHWR for their next orders...An initial programme of not more than 4000 MW based on reactor units of 600-660 MW would be launched and the first orders would be placed 'as soon as possible'." The possibility of further advanced gas-cooled reactor (AGR) stations or of UK participation in an international high temperature reactor (HTR) program was not precluded (the OECD Dragon Project in which the UK played a leading role came to an end in March '76) and the Nuclear Installations Inspectorate (NII) was asked to complete his examination of the generic safety issues of Light Water Reactors (LWR). But "...our first commitment to the future must be the success of SGHWR."

This decision appears definitive. It was made, however, in an environment of heavy debate as to the correct course, and there was considerable concern as to its implications for British nuclear marketing. This concern has continued. British operating experience, in marketable reactors, is limited to the AGR, and this experience is incomplete. Moving to the SGHWR would delay the attainment of a marketable system still further. Meanwhile the water reactors in the US, the pressurized water reactor (PWR) of Westinghouse and the boiling water reactor (BWR) of General Electric, were moving relentlessly into foreign markets. Would it be better to seek a position in one of these,

particularly the PWR? By the summer of 1976 there were rumors in the press that the SGHWR program might be cancelled. It was confirmed that a further review of the reactor program was being undertaken. Finally a year's deferment of an expenditure of about £40 million on the SGHWR was announced by the Chancellor of the Exchequer amongst other UK budget cuts--although much of it was covered by slippage in the design program. In July '76, these events led the Select Committee, already fully engaged in an inquiry into alternative energy sources, to embark on a separate and urgent investigation of the SGHWR program. Their report (First Report from Select Committee on Science & Technology "The SGHWR Programme", HMSO) appeared in December.

The Committee had taken testimony from The Secretary of State for Energy, The Central Electricity Generating Board, The United Kingdom Atomic Energy Authority, The National Nuclear Corporation and Nuclear Power Company, The South of Scotland Electricity Board, The Electrical Power Engineers' Association, and The Health and Safety Executive. It received written evidence from the Institution of Professional Civil Servants, the Association of Scientific, Technical and Managerial Staffs (Whetstone Nuclear Power Branch), the Electrical, Electronic Telecommunications and Plumbing Union, and C.A. Parsons and Company Ltd.

The Committee was clear in the alternatives: Go ahead with the SGHWR program or

> "(i) For Britain to withdraw from the nuclear power business, and base its future power programme on fossil fuels, together with such energy as is available from sources such as solar, wind, wave and tidal power, and strict energy conservation;
> (ii) In light of lower medium-term electricity demand estimates, for Britain to embark on no further thermal reactor programme for some time but instead concentrate effort and resources on the development of the fast breeder reactor (FBR);
> (iii) For Britain to adopt the advanced gas-cooled reactor (AGR) in place of the SGHWR and to proceed with construction according to the timetable planned for the SGHWR;
> (iv) For Britain to adopt the Westinghouse pressurized light water reactor, in place of the SGHWR and to proceed with construction according to the timetable planned for the SGHWR."

Concerning FBRs, the Committee concluded that "...it would clearly be misguided to stake everything on a reactor type which will still take a long time to develop commercially and which is still the subject of controversy on safety ground." Concerning AGRs, the Committee pointed to "satisfactory" operation of two UK AGRs and concluded that "If the Government conclude that the SGHWR programme should be cancelled...we would regard the AGR as the preferable alternative for the United Kingdom's thermal reactor programme."

Concerning PWRs, the Committee questioned the argument which had been advanced that PWRs are less expensive to build; costing is extremely complex but, suffice it to say, disagreement is rampant here. In safety matters, the Committee quoted from the opinion of the South of Scotland Board: "...to have a safe vessel it is essential to fabricate it well nigh perfectly, from well nigh perfect materials, and carry out well nigh perfect inspection throughout its life." In market potential, the Committee was content to let the UKAEA "admit that it is difficult to see how the UK can, at this late stage, become 'substantial' exporters."

The Committee report strongly supports the SGHWR program. "The Secretary of State should only decide to cancel the SGHWR programme if (i) it seems certain to be more expensive than other reactors designed to meet the same safety standards; (ii) there is clear evidence of significantly greater export potential for other reactors, and (iii) if it can be demonstrated beyond all doubt that on-site construction of alternative reactors can begin on the dates scheduled for the start of the Sizewell and Torness SGHWR's...."

The Committee further offered comments on decision-making:

"It is a sad reflection on our decision-making machinery, and on the quality of the expert advice given to successive governments, that, seven years after the last nuclear station

was ordered, and after extensive private and public debate, sufficient information is apparently still not available on any of these points for the country to proceed with confidence--at whatever pace--to the construction of new nuclear power stations.

* *

Despite past attempts to establish a fairly close relationship between customer and contractor our evidence has revealed a duplication of design functions...a confusion of financial responsibilities...a confusion of responsibilities in the safety field... We believe that the relationships between the various bodies involved have contributed substantially to the delays experienced in the preparation of an agreed reference design for the SGHWR and to the escalation of SGHWR costs."

It transpired, in passing, that the NPAB created in 1973 "to provide continuing and concerted advice on all strategic aspects of civil nuclear energy policy" and whose recommendation had been taken in the decision of July '74 had not met since that year. The Committee felt that the case for an effective NPAB had been strengthened and that the Secretary of State should once again consider the appointing of a new Board.

Parallel with the above chronology, intertwined with it as an important input to it, and equally interesting from a technical decision-making viewpoint, has been an exhaustive detailed assessment of the integrity of PWR pressure vessels. Initiated late in 1973 by the Chairman of the UKAEA, this was undertaken by a special LWR Study Group (LWRSG) under the Chairmanship of Dr. W. Marshall, then the AEA's Member for Research and now its Vice Chairman. The LWRSG's terms of reference--"to establish the 'integrity' of LWR primary reactor pressure vessels and by examining and reporting all the appropriate facts, to draw conclusions about the mathematical probability of vessel failure and its dependence on these relevant factors" focus on an issue highlighted by Sir Alan Cottrell, then Government Chief Scientist, in a memorandum to the Select Committee at the time of its 1973-74 inquiry.

> "Rapid fracture, from large cracks or defects in thick sections, is in principle, possible in steel pressure vessels under operational conditions. In LWR vessels the estimated critical crack size for unstable growth is smaller than the wall thickness, so that the 'leak-before-break' safety feature is unavailable. In these circumstances, the security of an LWR vessel against fracture depends on the maintenance of rigorous manufacturing and quality control standards; and on thorough, effective and regularly repeated examination of the vessel by the ultrasonic crack detection technique. The possible gradual growth of small cracks in highly stressed regions, by ageing and corrosion effects during service needs further scientific investigation, as also does the effect of thermal shock from emergency cooling water in a loss-of-coolant accident."

At that time the CEGB in particular had favored the introduction of LWR's as developed in the US and particularly the PWR marketed by Westinghouse Elec. Corp. Concern had been expressed on two specific issues.

> (i) In the event of a major rupture of the primary pressure circuit, would the emergency core-cooling water system (ECCS) be able to prevent the nuclear fuel elements overheating, and releasing their fission products?
> (ii) Could the pressure vessel, which contains the nuclear core, fail catastrophically?

The LWRSG reported to the UKAEA in the summer of 1976. An extensive summary of their report covering all major points dated 1 Oct 76 is available and is commended to all concerned with large pressure vessel design and construction, and to students of the technical decision-making process. (An Assessment of the Integrity of PWR Pressure Vessels, 1 Oct 1976, HMSO, £3.50.) The conclusions of this exhaustively comprehensive, painstaking and detailed study are presented under four headings

> (i) Reliability under normal, upset and test conditions
> (ii) Reliability under emergency and fault conditions

(iii) Variation of failure probability with age and
(iv) Quality control

The conclusions are supplemented by and interrelated with some 40 recommendations classed as "Essential" and grouped under headings of General, Design, Manufacture, and In Service, and some 25 others classed as "For Improved Confidence". Most of the recommendations are specific and technical (e.g., "Forgings should be made to SA 508 class 3 specification"). Some of the more notable ones: "The present evidence indicates that even with good quality control of fabrication procedures and inspection to ASME rules, the resulting vessel has an appreciable chance of containing a sizeable defect.... The emergency safety injection system should inject water at as high a temperature as compatible with other requirements with the aim of reducing the thermal shock during a large LOCA [loss-of-coolant accident]....Fracture toughness tests be included in the UK surveillance programme....NDE (non-destructive examination) according to ASME III should be carried out and supplemented by extensive ultrasonic tests....A procedure based on sound experimental evidence for dealing with defects found in installed vessels be established before the operation of PWR's be allowed in the UK....Firm limits on the size of 'acceptable' defects be agreed before any UK vessel be installed....Further development of acoustic emission techniques should be carried out, with a view to applying them in any pressure test and also to using permanent sensors to detect and monitor growth of any cracks."

It was not in the charter of the Study Group to recommend concerning the adoption of the PWRs over SGHWR or other options, merely to investigate matters of integrity. Yet the report appears to have weighed-in for the adoption of PWRs. The report itself has been forwarded to the Nuclear Installations Inspectorate for consideration with other inputs.

An exchange of letters between Marshall and Cottrell is annexed to the LSWRG Report. Marshall, by a letter of 18 June 1976, transmitted an advanced copy of the LWRSG report to Cottrell, inviting his comments, stating that the report is a "major justification of your original viewpoint." He went on "However, we have now completed our studies and we fully understand the large amount of work that has been done on this subject, primarily in America, but also in Germany, France and Japan. In addition, we have completed a large number of calculations of our own, and we have come to a unanimous conclusion that satisfactory answers to your questions can be provided. Subject to a number of considerations we recommend that it would now be possible for the Nuclear Inspector to be satisfied about the safety of the pressure vessels for any PWRs built in this country. Of course, the Nuclear Inspector would have a large number of other factors to take into account before arriving at an overall view upon whether these reactors could be licensed in the UK."

Cottrell, replying a mere three days later, commended the Group with the statement "It is a first-class report, impressively thorough and objective. Your Study Group has done an excellent piece of work." However, he then continued "Of the many important technical points made in the Report I found three particularly striking because of their newness; i.e.,

(i) That it is essential to confine the operational transients to unusually narrow limits in order to avoid excessive crack growth by metal fatigue.
(ii) That emergency core cooling water should be injected at an unusually high temperature in order to minimize the risk of fracture by thermal shock.
(iii) That rigorous ultrasonic inspection of the pressure vessels could reduce their probability of failure by a hundredfold and that, without this inspection, the probability of PWR vessels failing, under their operational conditions, is significantly greater than the upper limit for non-nuclear vessels."

Cottrell concludes that "I am in general agreement with the technical content of the Report itself."

Subsequent correspondence from Cottrell to the Secretary of State for Energy dated 3 Aug and 7 Sept '76 and from Marshall to Cottrell dated 30 Sept '76 are reproduced as annex to the 1976 Select Committee report

referred to earlier in this ESN. Cottrell concludes his letter of the 3rd Aug: "In my opinion, the technical position does not guarantee that these pressure vessels will be able to operate safely for the full design life of the reactor. Of course, it is difficult to guarantee the metallurgical performance of any engineering component over some 30 years of arduous life; but the great difference in this respect is that a pressure-tube reactor such as...SGHWR is demountable--defective tubes can be taken out and replaced by new ones--whereas the monolithic steel pressure vessel of the LWR is not."

As a whole the correspondence reveals crucial differences of interpretation of the LSRWG report as it relates to crack growth and operational transients, albeit as suggested by Marshall they may be reconcilable.

This rendition of the chronology of the nuclear debate in Britain necessarily omits much important detail and many important arguments. It aims to outline a very complex problem and to offer the UK nuclear reactor program as an interesting case study in decision-making in an area where technical questions are particularly important.

The inquiry and the debate continue. (Al Sosin and A.W. Pryce)

4TH WORLD CONGRESS OF ENGINEERS AND ARCHITECTS IN ISRAEL

What with the variety of tourist-type activities laid on, the Congress actually ran for about eight days, although the working part of the meeting consisted of plenary and panel sessions convened from 14-17 December at the Tel-Aviv Hilton. The theme was "Dialogue in Development--Concepts and Actions".

The Congress is administered by the Association of Engineers and Architects in Israel and the Chairman was AEAI President, Mr. E. Pelles. A co-sponsoring agency was the International Technical Cooperation Centre (ITCC), an Israel-based organization that was an outgrowth of the first Congress held nine years ago. This time, according to local press releases, some 2000 delegates turned up, 700 from 62 countries other than Israel. There were delegates from 12 African and 10 Asian countries, many of which have no diplomatic relations with Israel, a point emphasized by Israel's President, Prof. Ephraim Katzir at the "Festive Opening Ceremony". Katzir, in fact, gave a most informative and enjoyable talk which, it turned out, was one of the best of the Congress. He characterized the various social eras of national development as agrarian, pre-industrial, industrial, and post-industrial. He pointed out many of Israel's problems, not the least of which is the desire of her people (and other Third World societies) to live in a post-industrial era, in which all receive equal shares of goods and services, without accepting the realities of the early industrial period in which they exist in fact.

There were four Plenary Sessions, all but one of which were chaired by Ministers of the Israeli Government. In each of the first three sessions there were five "key" lectures given by various prominent individuals from government, industry, and academia (10 of the 15 were from universities). These talks, of necessity, were quite wide-ranging and there was minimal technical depth--an excusable deficiency that would be remedied, I thought, in the panel sessions. The key lectures often tended towards political commentary and were over-burdened with motherhood statements ("planning should be integrated and comprehensive"), obvious truths ("people will want more and better housing"), and jargon ("panoramas of options"). The final plenary session was for the purpose of summarizing the panel discussions and, as one of the few who had persevered to the end, I heard most panel chairmen recite a list of paper titles presented at their panels.

The 15 subject areas defined for the panel sessions covered various aspects of social and industrial development--resources (manpower, water and energy), housing, education, land use, civil and structural engineering, communications, environment, transportation, planning, decision processes, and architecture. The panel sessions actually consisted of a series of mini-conferences with the reading of yet more prepared papers. There were 210 abstracts of papers submitted for presentation at the 15 panels, with about 3½ hours available for each panel session. One

panel (Architecture and Urban Design) had 27 papers scheduled! Fortunately (as one panel chairman put it) there was a large amount of absenteeism among the authors so that the situation was alleviated somewhat. Even so, there was little opportunity for the dialogue advertised in the theme. The panel sessions that I attended (Water Resources Development, Energy Resources--Alternate Solutions, and Civil and Structural Engineering) were short on engineering content, even though I selected them with high hopes. In the Panel Session on Civil and Structural Engineering, for example, there were two papers (given by US authors) describing various building codes in the US and lauding the concept of the building permit.

Engineers and scientists are often criticized--frequently by each other and themselves--for not playing a more active role in the planning and policy-forming phases of national, regional and local programs. The AEAI/ITCC Congress provided some insights into the paradoxical reasons for this non-involvement. The "soft sciences" often contain a fair amount of what sounds to us, as engineers and scientists, like subjective, platitudinous hocus-pocus--something that both repels us and accents the need for our interaction. For us to participate we must first become apprentices in trades in which magniloquence is accepted, even glorified. Unfortunately, the club must be joined before the by-laws can be amended. (Robert H. Nunn)

MATERIALS SCIENCES

METALLURGY AT THE UNIVERSITY OF KARLSRUHE--EMPHASIS ON CONVENTION

The Institut für Werkstoffekunde at the Universität Karlsruhe, under the direction of E. Macherauch, is cast in a conventional metallurgy department mold. Efforts to extend its scope to include polymers have been largely unsuccessful; metals are the central theme, and attention is restricted largely to steels and copper alloys.

Measurements of mechanical properties (e.g., stress-strain curves) dominate research activities. For example, dynamic tensile tests of α-Cu (Al, Ga, or Ge) alloys have been run at various strain rates and in stress-relaxation tests in the temperature range between 78 K and 363 K. The data are analyzed to yield the free activation enthalpy for the interaction of glide dislocations with solute atoms. The enthalpies vary from 1.2 to 1.9 eV, depending on solute type and concentration (1.22 eV for 3.4% Ga vs 1.67 for 1.2% Ga). The quantity monitored in this work was the stress for 0.2 strain offset. The serrated yielding phenomenon, the Portevin-Le Chatelier Effect, has also been examined as a thermally activated process. This effect is linked with interstitial diffusion in steels but, in copper-based alloys, the Karlsruhe investigators identify the elastic interaction between glide dislocations and solute atoms enhanced by non-equilibrium vacancies produced by plastic deformation or simply in thermal equilibrium. Under these assumptions, the Portevin-Le Chatelier studies allow the deduction of vacancy-solute atom binding energies, which have been studied in Cu with additions of Zn, ZnNi, Sn, Al, Ga, Ge, As, and In by Macherauch *et al*.

Related studies include the influence of grain size and texture in α-Cu(Zn) and of twinning in α-Cu (Zn, Ga, As, Sn). A critical stress was identified for twinning; this stress is approximately proportional to the square root of the stacking-fault energy (adjusted by alloying) and the inverse square root of the grain size. The latter relation follows a prediction of the much-used Petch grain-size equation.

The studies in steel, under H. Wohlfahrt, concern processing in technological situations. He has studied fatigue of an annealed low-carbon steel as influenced by the sample preparation method--up-cut and down-cut milling. Since surface conditions are thought to dominate fatigue fracture, Wohlfahrt determined the residual stress state at and near (<60 μm) the surface by x-rays. Although the same hardness was found in either milling treatment, the stress pattern

differed entirely; a tensile stress of +210 N/mm^2 was measured at the surface of the down-cut surface while -300 N/mm^2 existed at the up-cut surface. Nevertheless, no substantial difference was found in the fatigue tests. This would appear to violate the familiar dogma that compressive stresses increase fatigue strength. (Al Sosin)

THE NEED FOR NEW WELDING PROCESSES--ARE WE AT THE END OF THE OLD ROAD?

One-hour lectures at the Royal Society in London are generally restricted in technical content or depth by time limitations and audience diversity. An address on 10 Feb 1977 by R. Weck, Director of the Welding Institute and a Fellow of the Society is, nevertheless, noteworthy for the important point the speaker sought to develop. His thesis, stated briefly, is that we have reached a point of diminishing, perhaps near-zero, returns in developing and utilizing most of the conventional welding techniques. It is time to move on to new methods. According to Weck, this view is a personal one, not shared by most authorities, and even scorned by them.

Weck pointed to the elements in the progress of welding which have brought us to the present state. The simplicity, convenience, increased productivity, and economy of welding provided the original impetus for its general acceptance over previous techniques such as bolting or riveting. Then two major attributes of welding were recognized. Materials of thicker section could now be joined. Consequently, the size of attainable equipment surged forward, leading to bigger plant size, in turn. The economies of size followed. A second attribute is the leakproof character of welds. It became possible to move to higher pressures and temperature, to achieve better vacua, to handle more hazardous materials, etc. More recently, public consciousness of health hazards has provided another incentive for developing welding still further. With this backing and motivation, welding research has stepped up its pace considerably, and many of the details of welding processes, comprising a vast panoply of variables, have emerged. At the same time, the demands on the final product have increased. Excellence of finish is no longer merely a matter of esthetics.

As vast as the consequences of current welding techniques have been, so too have been the problems, and Weck (unfortunately) spent most of his time illustrating defects in fusion welding in steel as a particular example. With the aid of slides he described laminar tearing due generally to MnS and other inclusions. This can be minimized by eliminating S, which is expensive, or adding Ce or Mischmetal, a practice that cannot be used in continuous casting. Cracking due to fabrication stresses can be largely eliminated by stress-relief heat treatment, normalizing, addition of aluminum (to refine grain size and increase notch toughness), and controlled rolling. These examples relate to cracks or incipient cracks introduced into the steel components during welding. The weld is, in itself, subject to cracking, of course, due to the large contractions which occur in the melt zone on solidification. Reheat-cracking is a current major concern in low-carbon steels used in nuclear light water reactors; here the crack develops during thermal cycling in service.

The above litany may seem to be a familiar recitation of material limitations which may be overcome by more research and better practice. Weck does not ascribe to this. He believes that the simplicity that came with welding has been largely dissipated. The movement to phosphorous-free steels, for example, the use of inert atmospheres, the additional control of hazardous fumes--these are but a few of the complications and strictures that have been introduced. Indeed, as Weck pointed out, the conditions for more exotic welding are beginning to approach those of pharmaceutical standard. Further, research results, which continue to flow in, point to still more refinements that should be made if feasible. Even testing is no longer simple, if applicable at all. Results obtained with the use of (relatively) small Charpy test samples, the standard for testing over the years, show little correlation with results obtained from the use of more realistic, much larger, and very much

more expensive "crack-opening-displacement" sample testing. To this must be added the mushrooming surveillance and detection methods (e.g., ultrasonics) with their significant incremental costs.

It is time to look elsewhere, according to Weck. Electron-beam welding is an attractive alternative, where applicable. This involves little or no sample distortion and no hydrogen introduction. It is limited by size (up to 200 mm thickness) and cost of equipment (approaching $1-2 M for large installations). Electron-beam welding is rather well developed. Alternatives such as friction welding and diffusion bonding, which do not involve melting, need more research and development, and Weck strongly advocated this, an advocacy that may not be too surprising considering his position. (Explosive and roll cladding are two more examples of non-melt welding.)

Have we reached the end of the old road or are we still approaching the end? This was the generalization of a question put to Weck in the post-lecture discussion. Specifically, are the welding demands in the case of the pressurized water reactors beyond the present capability to achieve zero-defect performance? An interesting and very timely question, indeed! Unfortunately, Weck chose statesmanship to advocacy; the answer was not forthcoming. (Al Sosin)

MEDICAL SCIENCES

A SYMPOSIUM ON CARBON DIOXIDE AND BREATHING

Why should there be a symposium on carbon dioxide (CO_2) and breathing, and who would wish to organize it? Let's think crudely of man as a black box provided with a bellows for taking up oxygen and ejecting CO_2 generated in some way by the input of oxygen. Invisible built-in controls buffer the inside of the box (the "milieu intérieur" of Claude Bernard) against external changes, so that oxygen uptake and CO_2 release are maintained at fairly constant rates over a whole lifetime. If we wish to learn about what goes on inside the black box, one way is to threaten its ability to regulate its contents (homeostasis) by restricting supply of oxygen, or by hindering the discharge of CO_2, or both. The bellows will have to respond in a manner reflecting in some way the gross features of the internal mechanism, and if there is something wrong with the mechanism the reaction to these external challenges may be expected to change.

A caricature, no doubt; but it points to a key role for CO_2 as an experimental tool and as a clinically useful diagnostic (and possibly therapeutic) aid. The human black box is, of course, not totally inviolate--a point hardly in need of belaboring--yet at the same time not totally available for tampering. Physiologists and physicians would be badly off if their only experimental subjects were volunteers (including themselves) and patients. Fortunately, animal experimentation, in which CO_2 has often played a key role, has revealed a lot about the internal mechanisms and, despite practical and conceptual limitations of its own, has provided a vital input for human normal and abnormal respiratory physiology.

So it is not surprising to find clinical respiratory physiologists interested in CO_2 and anxious to keep informed about data and ideas derived from animal--and this often means academic--physiology. This desire for a confrontation between the two groups to their mutual advantage was one important reason for an organization of clinical physiologists to convene a symposium on "CO_2 and Breathing".

The organization in question is the European Society for Clinical Respiratory Physiology, to be described in another article. The symposium was held in Warsaw, 13-15 September 1976. It was attended by 70-80 persons of whom a majority seemed to take an active part. Naturally enough, the Warsaw school was prominent; there were interesting papers from Turkey, Czechoslovakia, Hungary, Bulgaria, Italy and the Netherlands, and one from France. Despite the resulting pan-European flavor the gathering was dominated by the British and the W. Germans and by the outstanding Swedish physiologist C. von Euler (Karolinska Inst., Stockholm). The advantage

earned by the superior work of these people was reinforced by fluent delivery and, no doubt, by natural spontaneity in making their comments in the English language. I was the only American present, simply by the accident of long-time membership in the Physiogical Society (UK), which qualified me to observe the proceedings of this essentially European meeting.

I propose here to give only a rather disjointed series of impressions picked up during the technical sessions and at mealtimes. To begin with, the black-box approach already mentioned is not as outrageous as it may seem; the types of respiratory function test that can legitimately be done on patients are strictly limited and there are some people who feel that any procedure that causes discomfort to a patient is unjustifiable if its main purpose is to satisfy scientific curiosity or ambition without any possibility of altering the inexorable course of obstructive disease. At the same time, the system of regulation of breathing is so extraordinarily complex that the information obtainable from non-invasive tests is limited, more or less, to the mechanical performance of the lungs as a mixing chamber and to the effectiveness of the blood-gas interface.

I write "more or less" in order to deflect criticism of the last statement, or to anticipate it by remarking that the act of breathing is in fact a response to many nervous and chemical signals transmitted to certain elements in the brain stem and processed there to formulate instructions which are issued to the muscles of the ribs and diaphragm and to the heart and blood vessels. So it is conceivable that careful analysis of breathing patterns and their responses to inhaling CO_2 and to lack of oxygen will help in unscrambling the contributions of the various sensitive nerve endings ("receptors"). Some of these are sensitive to mechanical stretching, some to airway irritation, some to local congestion, others to chemical stimuli. Some are situated near the main arteries, some in the lung capillaries, in the lung alveoli and air passages, while others lie at different functional levels in the brain stem. This approach has in fact been used, notably by D.J.C. Cunningham, E. Strange-Petersen and their colleagues at Oxford. Although it requires elaborate experimental design and statistical treatment of physiological and non-physiological noise, it may prove useful in finding whether responses to particular stimuli arise from receptors in the chest or are delayed to the extent needed for the blood to carry the chemical signal to the brain.

Experiments of this type, if they could be shown to generate clinically significant information, might go far towards relieving the patient of the burden of "invasive" tests. However, it has long been known that distractions associated with quite mild experimental procedures, such as the use of mouthpieces or nose clips or changing from one external gas circuit to another, may produce greater changes than those arising from the primary reaction in the brain stem, especially in resting subjects. There is now a tendency to move away from intimidating test apparatus and from the patient's cooperation in performing some of the test maneuvers, but it is unlikely that any environment will be devised to eliminate conscious influences entirely. A computer-assisted magnetometer which does not interfere with the airway has been used by J. Newsom Davis (National Hospital for Nervous Diseases, London) to record the breathing of a subject lying in a controlled atmosphere. Even under these favorable conditions, the ventilatory response to inhaled CO_2 was greater when the subject was conscious than during ordinary "slow" sleep, when the "behavioral system" is quiescent.

The mechanical aspects of breathing in normal persons and in a variety of abnormal states have attracted the engineers, who have spotted a lucrative market for elaborate equipment with which to test lung function and to perform artificial ventilation. Harsh words were spoken about the proliferation of controlled breathing devices furnished with elaborate data displays, visual alarms and so forth, which impede and confuse the clinician by their lack of relevance to the still imperfectly understood physiological basis of respiration. On the other hand, real advances are being made by the clinical physiologists themselves, particularly in dealing with patients who after a long period on the ventilator may have laboriously to be "weaned" back to normal

breathing. The most notable feature of these advances, it seemed to me, among several described by J.F. Nunn (MRC Clinical Research Centre, Harrow, Middlesex), was the computer-operated servo ventilator so designed that it is automatically bypassed whenever spontaneous respiratory effort intervenes.

Most of the papers on the clinical significance of CO_2 dealt with experimental stratagems for determining how and why the reaction to CO_2 is modified in various abnormal conditions. A friend once told me that he had observed temporary cessation of breathing (apneusis) in bronchitic patients given pure oxygen. Results of recent work in physiology, he said, providing the clue to this previously inexplicable phenomenon, would eventually filter down through the textbooks to the practising physician. The clue in question is an apparent loss of sensitivity to CO_2 so that the only respiratory drive available to the bronchitic after his lungs have been filled with oxygen is generated by the hypoxia (oxygen lack) which develops as the oxygen is used up. The nature of this apparent loss of sensitivity to CO_2 was one among many topics considered. Two groups of workers measured the maximum rates of development of pressure at the onset of inhalation, R(max), by introducing a slight transient impediment (A.W. Matthews *et al*, Southampton U. Hospitals, UK) or a complete block (L. Marazzini *et al*, Ospedale Maggiore di Milano and Ospedale Città di Sesto S. Giovanni, Italy) into the respiratory circuit at the right instant. The data were obtained in a few tenths of a second, before conscious effort was produced and reacted to, and were assumed to provide a measure of central respiratory drive. Both groups agreed that the change in R(max) produced by CO_2 is less in chronic bronchitics than in normal persons, but while Matthews considered this to indicate decreased central sensitivity to CO_2, Marazzini was led to the contrary conclusion. The effect, he said, is due to "failure of the thoraco-muscular system to convert the output of the respiratory centers into an increase of pulmonary pressure and ventilation". So the matter remains unresolved.

Much more should be written about the clinical discussions, but it is time to turn to the academic physiologists whose animal experiments, cutting open and sometimes dismantling the black box, have provided most of the conceptual framework for clinical respiratory physiology. The academics came in for some criticism from one of themselves, von Euler, who reproached them for ignoring the networks of nerve cells in the central nervous system which are involved in the control of breathing, with the sad result that nobody knows "the whole book" of respiratory physiology. At another point in the discussion von Euler remarked also upon the unique character of the respiratory maintenance of a stable "milieu intérieur" arising from the fact that there is a superstructure of conscious muscular control, which influences and partly bypasses the mechanisms operating at lower levels in the nervous system (pons and medulla oblongata).

Several papers dealt with the properties of respiratory nerve cells in the medulla, some groups of which had been localized, identified morphologically and characterized physiologically by von Euler himself and coworkers. Chemical signals carried by the blood and cerebrospinal fluid and nerve signals from peripheral receptors reach the respiratory centers and contribute to the information which must be processed centrally in order to generate outgoing impulses controlling ventilation. An important paper by H.H. Loeschke (Inst. f. Physiologie, Ruhr-Universität Bochum, FRG), who was unable to be present, would have dealt with his experiments in greater detail than could be given in the abstract. These showed that intracranial chemosensitivity is confined to two areas on the forward-facing (ventral) surface of the medulla. The impulses originating here are transmitted to the respiratory centers and can be blocked by cooling or anesthetizing the line of communication. H.P. Koepchen (Inst. Physiol., Free U. Berlin, FRG) confirmed and elaborated this finding, showing that receptor sensitivity to hydrogen ions is the basis for the effect of CO_2 on breathing. He identified nerve cells which control the drawing-in of air to the lungs and which are mainly responsible for the rhythm of breathing, and others, controlling the expulsion of air, which intervene only

in special cases of disturbed balance, since deflation of the lungs is a passive process *per se*.

Von Euler described an elegant series of experiments, with Teresa Trippenbach, bearing upon his hypothesis that the switching-off of nerve impulses which issue the signal to continue drawing in air results from the combined action of an automatic central rhythmic activity and the input *via* the vagus nerve from the "strain gauges" (pulmonary stretch receptors) in the lungs. They made use of the fact that the phase-switching mechanisms for inhalation and exhalation can be turned on by stimuli passed down from certain nerve cells in the pons, the structure next in line to the medulla as one approaches the brain from the spinal cord. These cells can be stimulated electrically (e.g., 0.5 ms pulses at 300 Hz for 0.2 s), and the voltage required to stop breathing-in varies rhythmically, being greater in the early stages of inhalation. Removal of vagal (pulmonary) stretch receptor input made it necessary to increase the stimulus. This seems to prove the postulated existence of an ingrained periodic sensitivity to "switching-off" of inhalation which can operate if necessary in absence of incoming impulses from the vagus nerve. The effects of CO_2 were studied, with results that explain the increased depth of breathing when CO_2 is inhaled and--when stretch receptor input is intact--are consistent with the observed increase in the frequency of the respiratory rhythm.

In all this, little was said about the intimate mode of action of the receptors sensitive to chemicals, partly because little is known and partly, one suspects, because the group was not biochemically oriented. The existence of chemically sensitive receptors such as those studied by Loeschke is of some interest since the central nervous system as a whole is notable for the rather elaborate mechanisms, by way of fluids filling the hollow places in the brain and spinal cord, to buffer it against chemical and physical disturbances. U. Pontén (Dept. Neurosurgery, The South Hospital, Fack, Stockholm, Sweden), while not addressing this problem directly, reminded us of the biochemical consequences of breathing CO_2. This leads to hypercapnia, the internal accumulation of chemicals derived from CO_2 while breathing too hard leads to internal depletion. The resulting changes of blood chemistry and blood flow lead by several mechanisms to changes in the utilization of internally generated substrates and so to alterations in intracerebral production or utilization of CO_2. The concentrations of chemical intermediates, some of which may be physiologically active, must also change. There was nothing to indicate that serious attention has been given to the role of brain metabolism and chemical transport in controlling excitability and integration of the central respiratory control apparatus, although an interesting paper by M.J. Purves (Dept. Physiology, U. Bristol, UK) touched upon metabolic factors influencing the width of cerebral blood vessels.

Most of the remaining papers were on the more familiar ground of the role played by intrapulmonary receptors in the effects of CO_2 and oxygen deficiency on ventilation and lung blood flow. An excellent review by Gwenda R. Barer (U. Sheffield, UK), drew attention to the effects of CO_2 on those muscles in the blood vessels, the lungs, the bronchi and the trachea which are not under conscious control. She concluded that all may be significant in maintaining a proper balance between ventilation and blood flow.

The more specialized papers on the results of analyzing the mechanisms of CO_2 effects by different methods illustrated, for this observer, the great variety of experimental tactics which is at once the strength and weakness of physiological research. Much discussion time was spent in trying to decide whether a result obtained with one species of animal would apply to others (including *H. sapiens*) or whether this or that discrepancy was due to different depths of anesthesia. Then there is that terrible, versatile, two-directional vagus nerve, the bugbear yet, in some eyes, the philosopher's stone of research on breathing. And what is one to say about the individualism of physiologists and their reluctance to repeat each other's experiments without making changes which can then be invoked to explain discrepancies and perhaps to justify another publication? It is that same individualism, of course, that leads to the inspired matching of ideas with the selected experimental object.

It was no accident that one of the most interesting papers, to me at any rate, was the one by P. Scheid *et al.* (Max-Planck-Inst. f. exp. Medizin, Göttingen, FRG) exploiting the anatomical simplicity of the tegu lizard lung, a simple sac-like tube, in their study of the regulation of ventilation by CO_2 receptors and stretch receptors.

A good meeting, which may well have gone some way to fulfilling von Euler's hope that an integrated research effort will be made to reveal "the whole book" of respiratory physiology. Unhappily, nobody undertook the task of trying to read a first draft of the book to us. It would have been worth the effort. (J.B. Bateman)

IMMUNE RESPONSES IN SCOTLAND

A one-day symposium entitled "The Genetics of Immune Responsiveness" was held in Edinburgh, Scotland, 20 December 1976. The meeting was organized by the Scottish Immunology Group, and held at the Edinburgh University Medical School. Although the weather was very chilly, the Scots exhibited their traditional friendly warmth, while emphasizing that Edinburgh University Medical School was THE center of medical education in the 17th, 18th, and 19th centuries--also that one of their distinguished medical alumni, Dr. James Crow, emigrated to the US and established, among other things, the production of Bourbon whiskey that bears his name. Amid this historic grandeur, the meeting was held to bring local physicians and researchers up to date on new developments in the field of immunology. About 100 people attended, with the majority of speakers being "imported" from England.

As background material, I will discuss a few of the more relevant concepts and then go on to the highlights of the meeting. In 1962, researchers made the important chance observation that rabbits of different strains differed in their ability to make antibodies to certain synthetic polypeptides. This observation led H. McDevitt, now at Stanford Univ. in California, to begin a genetic analysis in inbred strains of mice of antibody responses to these synthetic polypeptides. He was soon able to demonstrate that this particular immune response was controlled by a single autosomal dominant gene (or gene cluster) on chromosome number 17. The gene was subsequently named immune response-1, or Ir-1. With this knowledge in hand, animals could be divided into "high-responder" and "low-responder" groups on the basis of their genetic composition and ability to make antibodies. Similar Ir-genes were found to operate in other mammals, and evidence has since been accumulating that immune responses in humans are also under the control of Ir-genes, adding support to the concept of genetic homology between species. All this is important because we know that many human diseases are influenced by inadequate or excessive immune responses in the form of either humoral immune responses (antibody production) or in sensitizing the lymphocytes (cell-mediated reactions) to become destructive, and these most probably are under the control of the Ir-genes. The current vogue in immunology is to dissect these immune responses and ask at what cellular or molecular level this Ir-gene is exerting its function. Once this is known, the response is susceptible to beneficial modification. The meeting in Scotland dealt primarily with the level at which these Ir-genes are functioning.

David Lane (Imperial Cancer Research Fund, London), in a learned discussion on some of the current concepts surrounding Ir-genes, pointed out that while McDevitt's system utilized a synthetic polypeptide to probe the responses and found a single controlling gene, the responses to other more complex antigens such as red blood cells were known to be controlled by numerous genes. Many of these Ir-genes are located on chromosome number 17, within the major histocompatibility locus (H-2) of the mouse, containing genes which control synthesis of antigens involved in recognition of "self" and rejection of incompatible grafts. Others are found near genes coding for the immunoglobulin molecules most probably on different chromosomes altogether. Lane suggested that those genes located in the H-2 loci may have a quantitative effect on antibody production, while other Ir-genes may have a qualitative regulatory role. He mentioned other types of Ir-gene, some related to antigen, and a final

group that failed to fall into the three distinct types. It appears that there may be as many controlling Ir-genes as steps in the process of antigen recognition and subsequent antibody production, and the definition of these pathways will help elucidate the function of these genes.

Dr. A. White (Blood Transfusion Service, Edinburgh) spoke about the search for Ir-genes in man. As evidence for the existence of these genes he mentioned Rh-sensitization, where it is clear that some people respond very vigorously to a foreign Rh blood type while others do not. Equally compelling is the evidence for high and low responses to a variety of agents including vaccinia virus, tuberculin and certain types of influenza virus vaccine. Although these observations are suggestive, they have no genetic confirmation.

Dr. Colin Young (Queen Elizabeth College, London) presented a theory suggesting that high and low responses were not under genetic control at all, but rather that many antigens were similar to self-proteins and an animal would fail to respond because he was tolerant (unresponsive) to his own tissues. Evidence to support his theory of non-responsiveness due to "cross tolerance" came from experiments showing that antibodies against ferritin, a ferric protein which plays a regulatory role in iron metabolism, could be absorbed by cells from low-responder mice. The implication is that cells from such mice had some surface protein that resembled ferritin, and that low-responder mice failed to respond to ferritin by producing antibodies to ferritin because they were tolerant to this "ferritin-like" self-protein. His theory made certain predictions, one being that if one mated a high-responder with a low-responder, the offspring animals would exhibit an intermediate antibody response, which they did. The crunch came, however, when he presented results from matings between two low-responders, the prediction being they would exhibit low response, while in fact they made a high response. This was incompatible with the hypothesis, and indirectly lends support to the concept of genetic control of immune responses.

The final and most interesting work was presented by Sarah Howie (University College London). Using tissue-culture techniques, she is able to dissect the component parts of the immune response into the respective cell types that interact to produce antibody. It turns out that macrophages (large cells which can engulf foreign particles), thymus-derived cells (T cells) and plasma cells (B cells) all must interact. She showed that T cells secrete antigen-specific biologically-active factors that induce antibody formation in B cells, and that the T cells are dependent on macrophages for the ability to do this. With a pathway of this complexity, each stage being under genetic control, the importance of complementary Ir-genes is easily seen. She was able to show that some low-responder animals were unable to make the T-cell factor although their B cells worked perfectly well, whereas other low-responders had defects at the B-cell level. This sort of functional cellular examination of the component parts answers some puzzling questions, such as why a high-responder is produced when two low-responders are mated, the answer being Ir-gene complementation; i.e., those Ir-genes that control the macrophage T-B cell interaction must all be complementary or no response will be observed, a theory put forward some time ago by M. Taussig and A. Munro of Cambridge.

With studies such as these, where genes can be identified and shown to control biologically active factors, biology in general, and immunology in particular, is moving towards more sophisticated studies into interactions at the molecular level and their genetic basis. We are beginning to glimpse into the future when many of these biologically active factors might be subject to manipulation.
(James N. Woody, LCDR, US NAVACTSUK)

ONRL REPORTS

See the back of this issue for a list of current abstracts.

OCEAN SCIENCE & TECHNOLOGY

NORWEGIAN OFFSHORE TECHNOLOGY--SMALL IS BEAUTIFUL

Norway is one of the most sparsely-populated countries in Europe with a population of just over 4 million, in a land area about three times that of the state of Virginia. Only 4% of the land is tillable and more than one-third of it is above the Arctic Circle. Although Norway is only 1100 miles long, from north to south, her fjords and hundreds of offshore islands give her a coastline of about 12,500 miles (about equal to that of Australia).

Since the Bronze Age, Norwegians have excelled in the construction of swift sturdy vessels, and an affinity for ships marks every phase of their history. The sea which unites the country is also a boundless benefactor to Norway. The Gulf Stream provides enormous quantities of heat to warm the Norwegian and Barents Seas, to keep the fjords free of ice and to moderate the winter temperatures.

It can be argued that the discovery of oil in June 1970, in the famous Ekofisk field of the North Sea, has done more to challenge Norway's destiny than any other event in her history. Notwithstanding optimism born of oil wealth, the traditional conservatism of her people has tended to arrest sudden change and rather to lead to slow, well-thought-out steps, taken one at a time.

Thus, there is nothing dramatically new in the Norwegian philosophy towards her offshore engineering: oil provides a renewed stimulus to practice in her long-prized specialty, the sea. Radical changes are not evident; there are few new organizations, and most of what is new has grown out of existing establishments. Nevertheless, recent oil and natural gas discoveries, and the prospects for more finds in Norway's continental shelf above 62°N latitude, are expected to give considerable impetus not only to the economy but also to science and technology. Norway is already a net exporter of oil, and the stated policy is to build a science-based economy as a hedge against the inevitable exhaustion of the oil.

Today there is a concentration of expertise in the Trondheim region that represents a noteworthy capability for meeting a wide spectrum of industrial demands in the field of offshore engineering. The nucleus of this concentration is the Norwegian Institute of Technology (Norges Tekniske Høgskole, or NTH). NTH historically had its origins in the School of Mines which had been part of the University of Oslo since 1811. In 1900, the Norwegian Parliament established NTH with the aim of providing education for engineers and architects and to further the development of those branches of science and art which are pertinent to a technological education. In 1968 NTH was merged with three other bodies (the College of Arts and Science, the Faculty of Medicine and the Museum of the Royal Norwegian Society of Sciences) which together form the University of Trondheim.

A key organization for bringing the needs of offshore industry to the attention of NTH expertise is the OTTER (Offshore Technology Testing and Research) Group. It is a consortium which seeks to integrate the offshore technology activities of three independent R&D establishments in the Trondheim area: The Foundation for Scientific and Industrial Research at the University of Trondheim (SINTEF), The Norwegian Ship Research Institute (NSFI), and the Rivers and Harbors Laboratory (VHL). In our discussions with the director of OTTER, Mr. N. Sanders, he related how he and his staff of one have acted as "go-betweens" to effect the efficient transfer of problems, funds, and results between industry and the OTTER associates. Our visit to Trondheim included tours of the three OTTER associates, as well as the Continental Shelf Institute (IKU).

SINTEF. Of the three activities that constitute the OTTER group, SINTEF (Selskapet for Industriell og Teknisk Forskning) is by far the largest. It is an independent engineering foundation whose aims are to channel research to NTH and to undertake contract research itself. About half of the staff of 600 hold academic standing, and the annual budget, which has risen exponentially since the early 50s, now stands at about $12 M.

About 95% of these funds is derived from research contracts, two-thirds of which are with industry, the remainder coming from The Royal Norwegian Council for Scientific and Industrial Research (NTNF). Only 5% is furnished by direct government grants. SINTEF clients are largely Norwegian, but of the some 350 listed for 1975, 10% are from 12 foreign countries. Though SINTEF is economically independent, it is operationally tied to NTH: its headquarters are on-campus, it freely uses NTH equipment (in 1974 SINTEF purchased more equipment for NTH than NTH did), and there is a free exchange of students and professional staff between the two organizations. The 17 divisions of SINTEF, which are typically headed by NTH professors, cover everything from soup to nuts in technology. A partial list of these divisions includes chemistry, metallurgy, mechanics, structures, electronics, controls, computing, and metrology.

Our contact at SINTEF was Dr. I. Holand, head of the Structural Engineering Division and Professor of Civil Engineering. Holand is a contributor of long-standing to the field of structural analysis, and the efforts of his group in the use of the finite element method (FEM) in the dynamic analysis of offshore platforms are numbered among SINTEF's marketable products. Holand's main concern has been with the prediction of the response of the CONDEEP-type platform, which has a gravity foundation and three towers upon which rests a platform--all of concrete construction. The model now under development is fully three-dimensional and, with 59 nodal points, has 354 computational degrees of freedom. According to Holand, the modeling of such structures presents "modest difficulties" in comparison with the characterization of the sea, air, and soil that restrain and perturb them; i.e., the loading conditions have more uncertainty than the FEM model. His approach to these problems, and a brief summary of current methods, are documented in a recent report entitled "Dynamic Response of Framed and Gravity Structures to Waves", (SINTEF Report No. STF71 A 76030, 1 Nov 76). Although three CONDEEP platforms are now in place in the North Sea and three more are in various phases of production, we were surprised to learn that the first full-scale *in situ* data will not be forthcoming until the fall of this year. Though extensive sub-scale testing has been carried out, and no platforms have yet collapsed, these data are essential for the evaluation and improvement of the SINTEF analyses which, though highly sophisticated, contain many of the usual simplifying assumptions.

There are numerous other projects underway at SINTEF including the investigation of problems associated with welding (zone heating for local relief of weld stresses and the simulation of hyperbaric welding at pressures corresponding to depths up to 500 m); computer signal processing and analysis (long- and short-term wave data, and geomagnetic data for undersea prospecting); corrosion (inspection and protection systems); and ocean-bottom surveying systems for remote measurement of bottom strength characteristics).

SINTEF does not restrict itself to ocean technology. Projects range from sociological studies to automatic fish tracking. We were intrigued to find a project concerned with domestic heating by solar energy. With limited sun and lots of oil, this project has something of the flavor of Eskimos buying refrigerators, but it is also evidence of some commendable long-term thinking and flexibility in research.

VHL. This laboratory employs about 120 people, 55 of whom are professionals. The funding structure is similar to that of SINTEF, but the level is proportionately lower. Its affiliation with NTH appears to be less formal than that of the other two OTTER associates. The VHL (Vassdrags- og Havnelaboratoriet) dates back to 1958, when it replaced the NTH hydraulics laboratory, and since then has played a major role in the development of technologies associated with Norway's extensive system of rivers, estuaries, and fjords and, in particular, the massive hydroelectric network. These activities still play a major role in the VHL program, and the involvement in offshore problems, which has come relatively recently (with the oil), is generally limited to experimental evaluation of structural designs. The Laboratory is equipped with several standard free-surface flow facilities including two flumes, the largest of which is 1 x 2 m deep and 28 m

long, and two wave channels, the largest of which is 3.8 x 1 m deep, 78 m long, and equipped with a generator for irregular waves of up to ½ m in height.

Our host was the head of the Department of Harbor and Marine Technology, Dr. Alf Tørum. In reviewing the list of activities that he described to us, two projects seemed to be especially worth relating because of their intrinsic Norwegian origin.

The first of these had to do with the flow of fresh river water into the salt water of the fjords during the long Norwegian winters. Because of the difference in density and freezing point of the two fluids, inhabitants of fjords with too high a freshwater discharge from hydroelectric plants were destined to be ice-bound for extended periods. The problem was solved (to make a very long story very short) by the use of air injection systems to bubble air into the submerged salt-water layers and thereby promote vertical mixing. This was ten years ago and the systems are still widely used today. A more current problem just coming under study is that of wave generation by rock slides into the deep and tranquil Norwegian lakes. These slides, caused, for instance, by vibrations in transportation tunnels skirting a lake, are thought to cause waves of a nature that are sometimes intensified by the geometry of the lake walls. Severe wave damage has been noted on surrounding beaches.

In the area of offshore technology, VHL has conducted extensive wave-tank tests of sub-scale structures modeled after designs by Norwegian builders. The results are compared with available theoretical models, many of which are adapted from US computer codes. The testing is mainly intended to give confidence to the designs and is not categorized as research except when these designs are found to be wanting--and this happens. An example is the Ekofisk oil storage tank of French design which is a surface-piercing cylindrical tank that rests on the ocean bottom. In the hope of damping wave action on the tank, its designers had surrounded it with a perforated concentric shell in the belief that wave energy would be dissipated in the passage of water through the holes and by subsequent mixing in the annular region between shell and tank. Model tests showed that the effect of the shell was heavily dependent on the density and location of the perforations and could in some cases (and for some as-yet unexplained reason) actually intensify wave action. The shell was redesigned, retested, and finally installed at sea. Shortly after placement, Ekofisk experienced a "100-year" storm, and there are many who believe that without the VHL redesign it would not have survived. Ekofisk was a pioneer project in North Sea oil recovery, and had it failed there is little doubt that the rate of subsequent progress would have been severely reduced.

Projects relating to wave forces on large-volume structures constitute about one-half of the VHL work in offshore technology. The remainder of these are about evenly divided between at-sea current measurements, scour (the digging action due to water motion around the base of bottom-mounted structures), and pipelines (pipe-laying simulation, pipeline stability and survivability on the ocean bottom). In general, it can be said that in the offshore business VHL looks at problems associated with the response of stationary structures to the effects of the ocean environment. This specialty is nicely complemented by the moving-body interests of the NSFI.

NSFI. Almost adjacent to the NTH, at NSFI (Norges Skipsforskningsinstitutt) one can see the construction in progress to complete the Ship Technology Center described in the report by J. Breslin in ESN 28-7:254. (The completion date for the Center has slipped a year to 1977.) The NSFI employs a staff of 215 in the fields of naval hydrodynamics, ship design, shipyard planning, shipping operation, economics, and administration (in Oslo); marine control and instrumentation, materials protection (in Sandefjord), and offshore technology. This is an extremely impressive facility whose total capabilities are far beyond the scope of this article. Leaving the majority of the information to previous reports and NSFI literature, which is abundantly available upon request, we shall limit our comments to the expansion of facilities and the offshore technology areas.

Our tour was conducted by the Assistant Director, Dr. M. Gisvold. The Ship Technology Center is intended

to expand, integrate, and strengthen the already strong interactions between NSFI and NTH. At NSFI itself, there is to be a considerable expansion of its facilities which now consist mainly of the cavitation tunnel and the main towing tank, both of which are highly sophisticated and versatile. The first addition, scheduled for completion in 1977, is to be an 85-m extension of the present towing tank. This extension will make the total length of the 10.5-m-wide tank 260 m and will be variable in depth up to about 10 m. An entirely new facility will be the 50 x 80 x 10-m-deep Ocean Environmental Basin scheduled for completion in 1979. It will have simultaneous capabilities for wind, wave, and current simulation; and the current, which will be generated by recirculation, will be controllable at any angle to the waves. All operations will be computer-controlled; the waves, for instance, will be driven by signals which are generated by the standard NSFI method of selectively filtering white noise. The entire lashup--tanks, tunnels, and basin--will be known as the Ocean Environment Laboratories, and judging from the planned capabilities, a trip to this lab should be better than going to sea--in just about every conceivable way! One can certainly see the impact of petro-Kroners here.

NSFI has conducted an extensive variety of dynamic model tests of offshore equipment. These include drilling platforms, production platforms, pipes and pipe-laying vessels, mooring systems and submersibles. These tests often involve the towing, positioning, and mooring of such devices in which the full versatility of the tow-tank system is called into play. To cite one of many interesting results, it was found that for certain platforms and sea states, towing resistance in head seas can be smaller than in calm water. There is a mean drift force in the direction opposite to wave propagation and also opposite to that predicted by potential theory. Dr. E. Huse has constructed a compact and simple theory to show that a viscous drift force can occur whose sign depends upon the phase difference between platform pitch and the vertical component of relative particle velocity. His predictions, reported in NSFI Report R-45.76, are qualitatively verified by experiments.

IKU. To further the understanding of the Norwegian continental shelf and its potential resources, the IKU (Institutt for Kontinentalskkol-undersøkelser) was reorganized in 1975 as an independent institute within NTNF to undertake projects for both private and governmental sponsors. The Norwegian continental shelf (more than 300,000 square miles) covers an area equal to roughly one-third of the European continental shelf. Within this milieu IKU's main activities, which involve about 70 employees, include coastal wave and current measurements, ice movement measurements, pollution studies, bathymetric surveys, sea floor geology, marine geodesy, sub-sea inspection, reservoir engineering and mineral prospecting.

Considerable public concern in Norway has been generated by IKU's recent underwater survey of abandoned exploratory wellshafts. This revealed that the oil companies involved had not properly removed the concrete wellheads which, protruding from the ocean floor, had become the meeting place of fish and the ruination of trawlnets. The loss of these nets has been a serious matter to Norwegian fishermen, and video-taped pictures (obtained by the remote undersea exploration vehicle "SNURRE") shown on Norwegian TV, have resulted in strong national reaction against the oil companies.

The Norwegian national character seems to fit the mold shaped by Odin: "Praise no day until evening, no wife before her cremation, no sword until tested, no maid before marriage, no ice until crossed, no ale until drunk." In spite of the considerable internal and external pressure upon Norway to exploit her oil resources immediately and fully, she is not getting overly excited. She has, in fact, and continues to fund R&D from football pool revenues (ESN 30-4:167), and even that has proven effective. In the tradition that has led to her present prominence in offshore skills, Norway is pursuing a careful and well-organized program of technological advancement with due regard for long-term social, economic, and ecological effects. What she lacks in numbers she makes up for in quality and efficiency; and centers of excellence such as the

Trondheim region indicate technological capabilities that are more than sufficient to cope with her new-found riches. (Robert H. Nunn and LCDR John D. McKendrick, Jr.)

UNDERWATER TRANSDUCER DESIGN PROBLEMS

Any doubts as to whether difficulties are still being experienced in the design and fabrication of underwater acoustic transducers were certainly dispelled at a recent one-day discussion meeting on problems in transducer design organized by the Underwater Acoustic Group of the Institute of Acoustics. Held on 15 December 1976 at the University of Birmingham, the meeting brought together some 50-60 specialists in the transducer field (almost all from the UK), of whom about half were from industry and the remainder equally divided between universities and government service.

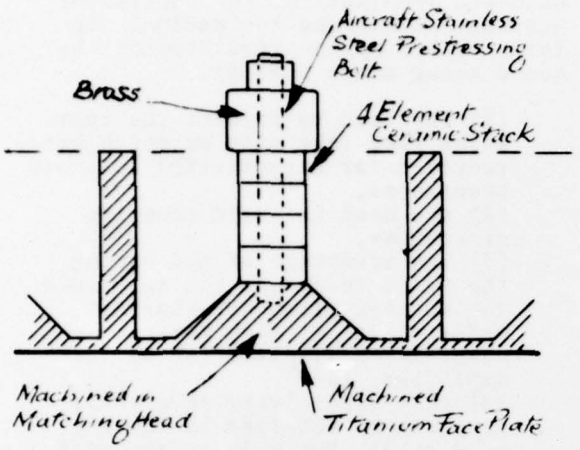
In addition to invited contributions on transducer design techniques and materials, a number of case histories were presented in which special design features and problems associated with them were described. To provide some structure to the meeting, an initial session dealt with low- and intermediate-frequency transducers; later papers covered materials and higher-frequency devices. In the event, the response in terms of contributions was such as to provide a very tight program which tended to restrict the discussion, at least that within the meeting. Possibly this was to be expected when dealing with a subject which covers such a wide range of parameters and factors--frequency, operating depth, active and passive materials, design, projectors and hydrophones, arrays, directivity, and cost, to name a few. It was still surprising, however, to find so many willing to discuss their difficulties.

D. Stansfield (Admiralty Underwater Weapons Establishment, Portland) opened the session on "Low and Intermediate Frequency Transducers" with a broad review based on his extensive experience with ceramics. He emphasized that the transducer must be treated as part of the total system with recognition of its role as receiver, transmitter or both, and with due concern for the electrical and acoustic interactions with the remainder of the underwater acoustic system and the medium. In terms of hydrophone requirements, he noted among other points:

(1) The need to segment the operating face (the size of which was required for directivity) to avoid resonances,
(2) the need to avoid mounting resonances,
(3) the advantage of not having the basic resonance too far above the working frequency range in order to use as much ceramic as possible--easing the job on the amplifier, and
(4) that directivity in a small size can be obtained by the use of dipoles, but only at the cost of sensitivity.

Outlining projector requirements--directivity pattern frequency range, power output, overall system requirements, size, weight, cost, corrosion, etc., he emphasized the need for good matching between the driving amplifier and the transducer, but said that there are occasions when a transducer can usefully be used away from resonance--the issue then being purely one of whether the required power can be put into it. He continued by discussing the use of equivalent circuits, stressing the value of the simpler ones, and by briefly reviewing various transducer constructions and types--arrays of loaded ceramic blocks, pistons - Tonpilz, magnetostriction, free-flooding rings, benders, etc. He concluded that the transducer problem is not in design as such, but in its engineering realization and in matching the transducer to the remainder of the system.

The first case study, presented by M.L. Somers (Institute of Oceanographic Sciences, Wormley), was a narrow-beam unit exploiting nonlinearity. Specifications included a 40-cm square working face at 80 kHz with an operating band of 6 kHz, high power and long pulse. Previous IOS experience had been at lower frequencies, and a decision had been made to scale-up a lower-frequency Rusby design. The 27 x 27 element design mounts the prestressed ceramic stacks behind a machined titanium plate as shown diagrammatically in the figure.



IOS Transducer Element (Diagrammatical)

Necessary considerations included maintaining the element separation as great as possible to reduce coupling, close-mechanical impedance matching and maintenance of the umbrella mode in the matching head at three to four times the operating frequency. Tolerances were a major problem as it was necessary to assure the design being within the individual fatigue limits both for the annuli around the face plate in the matching heads and for the prestressing bolts. This impressive design raised some question as to its appropriateness for production rather than for a one-of system, but it was pointed out that costs associated with machining the face plate to close tolerances were not unreasonable in terms of total system cost.

The case studies in this session continued with C. Llewellyn (IOS) outlining difficulties experienced in replacing a magnetostrictive scroll transducer in a bottom transponder with a piezoelectric unit, particularly with pressure release. R. Morris (Graseby Inst., Surbiton) then discussed the nature of the problems arising in scanning-sonar designs employing multi-element staves. A paper presented for M.W. Widener (Univ. Texas, Austin) on a multi-element high-powered array for parametric use emphasized the attendant internal heating problems and their effect on the design. V.G. Welsby (Birmingham Univ.) concluded the session by offering a modified ceramic stack element incorporating a leaf spring in the head which, however, has not been built.

The subsequent papers started with a valuable review by J.M. Pelmore (Birmingham Univ.) of passive materials used in transducer construction--backing materials, absorbants, adhesives, and windows. He included natural and silicone rubbers, the epoxy resins, with and without metal loading, and balloon composites. He noted the wide range of properties the composites offer and their value as backing materials. He said that while tungsten-loaded epoxies (*Sov. Phys. Ac.* 11, 55-59) are used in medical ultrasonic equipment, they suffer from air inclusions and are limited in their packing factor. Pelmore's paper included a considerable amount of new data determined at Birmingham.

J.R. Dunn (Birmingham Univ.) followed with a discussion of the general characteristics and problems of higher-frequency transducers and of the materials used in them. He offered a design of a 500-kHz directional unit as a case history. A paper presented for A.R. Pratt (Loughborough Univ.) reviewed the successive problems experienced in building a planar-scanning transducer for deep operation, including polystyrene foam, clamping pressure, oil leakage, and lifting of silver electrodes. These had led to a design within a nylon case, the window of which it is claimed can be cut to replace defective elements.

B. Woodward (Loughborough) discussed experience with PVF_2 as a piezoelectric, comparing it with PZT_4, and drawing comment from the floor that difficulty had been experienced with PVF_2 in obtaining consistent properties in manufacture.

Other case histories were outlined by N.G. Pace (Bath Univ.) who discussed impulse response, C.R. Hood (Min. of Agriculture, Fisheries and Food, Lowestoft), and R. Fischer (Ultra Electronics, High Wycombe). Hood reported difficulties using synthetic foam between elements in a large curved array, with attendent coupling problems, and loss of output at high power accompanied by Directivity Index changes.

The somewhat limited discussion resulting from the tight program was

noted earlier. The meeting left no doubt, however, that problems are still being experienced in transducer design and fabrication. Perhaps this is to be expected when every effort is usually made to drive a design to its limit in terms of material properties and engineering feasibility--because of the desire for more power output, deeper operation, etc., or acceptable cost. Experience and specialization play a major part in this field, and it is common practice indeed for many laboratories still to rely on their own experience rather than contract out. Beyond such issues, however, it must be noted that it is sometimes difficult to determine whether a failure is one of design, of inadequate material, of technique, or of engineering practice (for example, in sealing).

In conclusion, it is worthy of note that the question as to whether transducer design and fabrication is an engineering science or a black art is still being asked and that one must at least sympathize with those underwater acoustic workers tempted to resort to the incantation recalled by one speaker, "Bubble, bubble, transducer trouble!"

Proceedings of the meeting with a summary of the discussion are expected to be available from Dr. B.V. Smith, Secretary of the Underwater Acoustics Group, Dept. of Electronic and Electrical Engineering, Univ. of Birmingham, B15 2TT, England. Smith also has available proceedings of two earlier underwater acoustic group meetings: *Acoustic Surveying of Fish Populations* (meeting held at MAFF, Lowestoft, December 1975), non-members £3.00; and *Recent Developments in Underwater Acoustics* (meeting held at AUWE, Portland, March/April 1976), non-members £5.00. (A.W. Pryce)

THE NEW NATIONAL MARITIME INSTITUTE AND ITS FOCUS ON OFFSHORE RESEARCH

The National Maritime Institute, set up on 1 July 1976, was previously part of the National Physical Laboratory. Maritime experimental work previously carried out at NPL, with relevant staff and facilities in the hydrodynamic and aerodynamic areas have been transferred to the new organization, which is headquartered at the Ship Hydrodynamic Laboratory site in Feltham. Briefly summarized, NMI's interests are in that part of Ocean Engineering embraced by the study of the effects of ocean waves, currents and winds on fixed and floating structures. Emphasis is on practical application intended to derive maximum benefit for UK maritime and offshore interests from the unique facilities and staff expertise available. While an essential part of the Institute's work will continue to be the provision of scientific and technical support for legislative and regulatory purposes for the UK Government and other authorities concerned with shipping and offshore operations, support for the offshore industry--already a major role--is being especially encouraged.

NMI has available a full spectrum of water tunnel, tank, and channel facilities at Feltham and a wide range of wind tunnel facilities at Teddington, including a new wind/wave facility. In addition, a Marine Trials Station at Hythe (at one time the Hovercraft Development Laboratory) with supporting craft including a 200-ton research vessel permits ready access to the sea for direct environmental study, while a specially designed 260-ton wave-loading research structure has recently been completed and installed in Christchurch Bay.

These facilities and the research and support staff are available for R&D work to both government and industry on a customer/supplier basis via the Dept. of Industry (DoI). Operating on a pay-as-you-go basis, the establishment is expected to be self-supporting; it has, however, no direct authority to increase its staff to meet demand. More fundamental research is funded from a small budget or an allowance, the use of which is at the General Manager's discretion and may be used as research or "seed" money.

Particular attention is being paid to the problem of how best to respond to customers' needs for consultation and advanced R&D services, and especially of how to assure that customers are steered to the most appropriate research activity. An informal group has been formed for this purpose--the British Oceanographic Research Group which in addition to NMI includes the National Engineering Laboratory (NEL) with expertise in

maritime engineering, and the Hydraulics Research Station (HRS) with interests in offshore civil engineering. These three may be joined by the Building Research Station (BRS). NMI and NEL belong to the DoI, and HRS and BRS to the Dept. of the Environment.

Typical of the work being undertaken by NMI in the legislative and regulatory areas is a study of ship traffic in the English Channel, initiated in 1971 in response to public pressure. At that time no reliable estimate was available of the number of along-channel ship passages per day. This number is actually about 300, but knowledgeable estimates varied by a factor of 4. Continuous radar monitoring since that time with photographic records at 1 frame/minute have proved invaluable for a variety of ship studies in such areas as ship handling, maneuvering and routing. Presumably because of knowledge of the surveillance, wrong-way passages have been reduced by half. It was emphasized that this activity is not aimed at traffic control, but at providing advice to the Channel Navigation Investigation Survey (CNIS).

Other departures from strictly hydrodynamic and aerodynamic work have been into the human factors aspects of ship bridge layouts. Here the Institute has just completed a study which has resulted in "A Code of Practice on Bridge Design".

In large measure, the work of the Institute is dictated by the scope of the facilities available to it. Facilities built up over many years at NPL continue to be available for the traditional hydrodynamic and aerodynamic modeling work on ship and land structures--buildings, towers, etc., and for experimental modeling work on offshore structures. Recent additions such as the new wind/wave facility and a large-section wind tunnel permitting simulation of atmospheric wind turbulence substantially increase this modeling capability. The facilities for work at sea further increase the potential for support of offshore investigations, and as noted earlier they now include a specially developed wave-loading research structure.

The 260-ton wave-loading research structure, Fig. 1, installed in 8.5 m of water in Christchurch Bay is intermediate between a test model which can be tested in a tank and a full-size offshore structure. Sea conditions at Christchurch are similar to those in the North Sea in relation to structure size. Intended to serve a two-year program of wave-loading research and data acquisition for offshore structure designers, the highly instrumented tower was operated continuously between mid-September and mid-October 1976, successfully proving the instrumentation and acquiring valuable field data. On 14 October, some damage resulted from an exceptionally high wave, and the structure is now being refurbished.

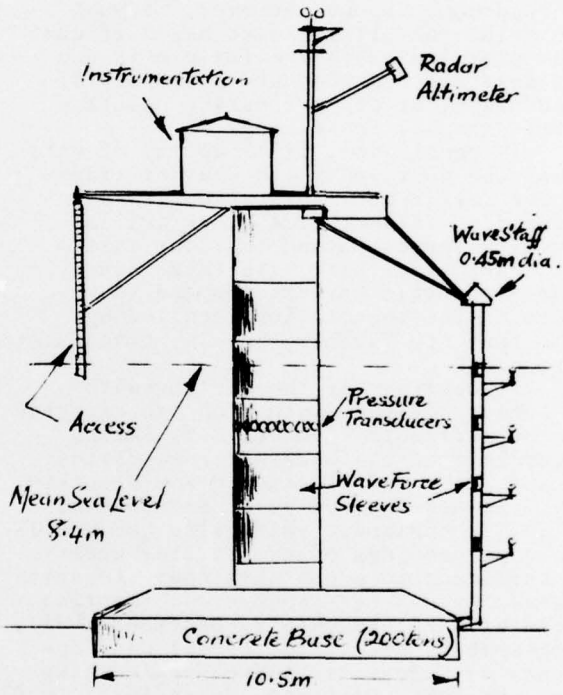


Fig. 1 Waveloading research structure & principal instrumentation

Provision is made on the structure for measurement of wave height, particle velocity and wave loading. Instrumentation for this includes a number of special NMI-developed transducers, e.g., a wave-loading force sleeve, and a perforated ball probe for measurement of particle velocity. Two of the latter at a given position permit determination of the absolute particle velocity in a 3-dimensional flow. When the system is in operation, 20 minutes of data are recorded every

3 hours, with 120 separate data channels taking about 12 samples per second per channel throughout the observation period. While the system is good to 8 Hz, cut off is at 3 Hz (50 dB down at 5 Hz) to prevent aliasing. On-site computer monitoring is employed, while a specially developed pulsed-code modulation system permits compression of the data so that 15 days data can be stored, although this has to be translated later for subsequent digital processing.

The program of research for offshore structures which this facility supports is financed from a number of sources including a consortium of oil companies, Det norske Veritas (cf. "Det norske Veritas" by J.P. Walsh, ESN 30-1:6-8) and the UK Government. It includes, in addition to the study of waves and wave forces by NMI, NEL studies on the behavior of structures and BRS studies of the soil mechanics associated with the supporting concrete base and sea floor. As a whole, the project provides an excellent example of (i) the pattern of the funding of the Institute's research, (ii) the Institute's cooperation with other activities in research projects and (iii) the Institute's and the UK's current major research thrust in the offshore area in support of North Sea operations.
(A.W. Pryce and LCDR John D. McKendrick, Jr.)

NEWS & NOTES

STRUCTURES

Two international conferences coming up in Norway (which means that ocean technology will be stressed) are: "Safety of Structures under Dynamic Loading", in Trondheim, 23 June - 1 July (reg. deadline 30 April--contact Conference Secretary, NTH, N-7034 Trondheim - NTH); and "Finite Elements in Nonlinear Solid and Structural Mechanics", in Geilo, 29 Aug - 1 Sep (contact Prof. P.G. Bergan, NTH, at same address).

MERGER

The Laboratoire de Detection Sous-Marine (DSM) in Le Brusc, France, has recently been combined with the former Groupe d'Etudes de DSM to form one body, the Groupe d'Etudes et Recherches DSM (GERDSM). The head of this Group is Ingénieur en Chef Lieutaud and H. Mermoz is the Scientific Director. Mr. P. Foache heads the Research Section and Mr. I.C.A. Adam is Head of the Developments Section.

THE INSTITUTE OF ACOUSTICS

In our December 1976 issue (ESN 30-12), we noted that the Institute of Acoustics (UK) with a membership of somewhat more than 1000 had established professional grades of membership of Fellow and Member, similar to those in other UK professional organizations. After reviewing applications from the membership for transfer to the new grades, the Institute elected about 120 Fellow and 280 Members. These numbers compare with a total membership of somewhat more than 5000, including 480 Fellows and 2650 Members, of the Acoustical Society of America. The ratios of total members to population and of Fellows to total membership are particularly consistent in the two countries, despite the fact that in the case of Fellowship in the UK, it is by application as compared with invitation in the US.

THE FUTURE OF EUROPEAN ELECTRONICS

Under the sponsorship of the German, British, Dutch and French governments, the consulting firm of Mackintosh Consultants (33 Burton Street, London W1) has produced a comprehensive report which predicts a very bleak future for the entire European electronics industry unless it is radically restructured. "With the possible exception of Philips", the report claims, there is no large and successful European producer of integrated circuits. Last year, over 90% of Europe's large-scale integration needs were supplied by US companies.

To counter the American domination of the electronics market the Mackintosh study recommends more international mergers among European countries and "much more financial aid from governments". The British Government, following the public release of the report, announced that electronic components are one of its five new "industrial strategy priority sectors", and that the Government's National Enterprise Board is involved in talks aimed at the possible merger of the electronic companies Plessey and Ferranti.

INCREASED EMPHASIS ON SOLAR ENERGY RESEARCH IN THE UK

Mr. Alex Eadie, Parliamentary Under-Secretary of State at the Department of Energy, announced on 18 February that the British Government will substantially accelerate its program of solar energy research and development by spending an additional £6 M (about $10 M) over the next four years. The main emphasis will be on the use of solar energy for domestic water and space heating. Three Government Departments will be responsible for various facets of the R&D program--the Departments of Environment, Industry and Energy. One of the main aims of the new program is to stimulate the application of solar power by funding the activities of commercial firms. The Department of Energy would provide up to half of the required funding.

THE FRENCH SOLAR ENERGY PROGRAM

The British decision to increase spending on solar energy R&D (see above) may have been influenced by recent publicity out of France. During the last week of January, the French announced the official opening of a 64 kW demonstration plant at Odeillo in the Pyrenees. At the same time, the National Research Center invited delegates from 26 Mediterranean countries and Gulf States to a presentation of what France has to offer in the way of solar energy plants. There was speculation that a "large contract" would be signed with Saudi Arabia.

Contracts of nearly $5 M each have been awarded to Renault and Saint Gobain to build 300 kW and 800 kW prototype plants to test different heat capture techniques. There is also discussion of the possibility of developing a 10,000 kW station.

ONRL CHANGES IN STAFF

We welcome aboard Dr. Vern N. Smiley, from the Laboratory for Atmospheric Physics, Desert Research Institute, Stead Campus, University of Nevada, who has joined our staff as Liaison Scientist for Lasers and Optics.

We bade farewell to Dr. Robert H. Nunn, who for the past nineteen months has been covering Mechanical Engineering for the Office. He has returned to the Naval Postgraduate School, Monterey, CA, where he is Head of the Department of Mechanical Engineering.

As so many of our readers are former Liaison Scientists and Naval Officers, or regular visitors to ONRL, we thought that they would like to know that two of the Support Staff, who have been with the Office since the early '50s, have retired. Mrs. Helen G. Fisher, who for the last six years was the Administrative Assistant in the Applications Division, retired on 9 November, and Mrs. Eunice Kelleher, who for the past 15 years has been a Secretary in the Sciences Division, retired 25 February. We are sure that all who knew these two ladies will join us in wishing them a long and happy retirement.

PERSONAL

Mr. John Alvey, currently Director of the Admiralty Surface Weapons Establishment, Portsmouth, UK, will become Deputy Controller, R&D Establishments and Research Controller and Chief Scientist (RAF) in April 1977. He will be well known to workers in the electronics field in the US; many will recall that in the mid '50s he was the UK's CVD Representative with the British Joint Service Mission in Washington, DC.

Mr. Alfred Champagnat, Engineer of the Arts and Measurements and Diplôme of the Ecole National Superieur of Chemistry, Strasbourg, has been awarded the Scientific Prize of UNESCO ($3000) for his work and discoveries on the massive and economic productions of new proteins from petroleum residues. The Prize, which is awarded every two years, is intended to recompense a person or a group of persons who have contributed in an exceptional manner to the development of the teaching of scientific and technical research or to technological industrial progress. Champagnat's research was concentrated on the production of proteins by micro-organisms that are nourished by the residue of petroleum distillation.

The title of Professor of Engineering Geomorphology has been conferred upon Dr. J.M. Hutchinson, Dept. of Civil Engineering, Imperial College, Univ. of London.

Professor N.H. March, Professor of Theoretical Solid State Physics, Imperial College, Univ. of London, has been elected to the Coulson Professorship of Theoretical Chemistry, Univ. of Oxford.

The title of Chevalier of the Order of Merit has been awarded by the French Government to Sir Nevill Mott, FRS, Honorary Professor of Experimental Physics, Cambridge Univ., and senior Research Fellow, Imperial College, London, and to Prof. Jacques Grosjean, Professor of Mechanical Engineering, Bath Univ., for their part in improving links between French and British scientists.

At the University College of Swansea, Univ. of Wales, Mr. T.R. Owen, Reader in the Dept. of Geology, has been awarded a personal Chair in the Department.

A personal professorship has been awarded Dr. John N. Sherwood, Reader and Director of the Crystal Growing Unit, Dept. of Pure and Applied Chemistry, Univ. of Strathclyde.

Prof. T.A. Villiers, Head of the Department of Biological Sciences, Natal Univ., has been appointed Professor of Biology at the Univ. of Salford from 1 August.

On 1 October 1976, three new Vice Presidents started their term of office at the Technion in Israel. They are: Prof. Moshe Zaki for Academic Affairs, Prof. Paul Singer for Development and Prof. Zeki Berk for Research.

OBITUARY

Prof. Edmund V. Telfer, pioneer naval architect, died 15 January at the age of 79. His early work on the presentation of ship model data gained him both a Master's degree and the first-ever PhD in naval architecture. He contributed many new words to the science, e.g., "geoism" and "esofrud". He was instrumental in the formation of the International Conference of Ship Tank Superintendents, now the International Towing Tank Conference, of which he was a permanent and enthusiastic member. He invented the Duplex rudder and one of the most successful and widely adopted propellers in the world, the Heliston. In 1946 he became Professor of Naval Architecture at the Technical Univ. of Norway in Trondheim where he remained until his retirement at age 70. From then until the present, he was very active in his consultancy practice.

ONRL REPORTS

R-14-76 OBSERVATIONS ON PSYCHOLOGICAL RESEARCH IN NINE BRITISH UNIVERSITIES by J.W. Miller

This report describes the results of visits to the psychology departments of nine universities. A brief survey of interests in the social sciences in the UK is included. The information is grouped into five categories: Ergonomics, Aids for the Handicapped, Vision and Perception, Man-Computer Interaction, and Other Areas of Psychology. In addition to describing specific psychology departments and research programs, comments are made about the direction of psychology in the UK and where, in the opinion of the author, its weaknesses and strength lie.

R-1-77 THE MARINE GAS TURBINE--THE UK PROVIDES A CASE STUDY IN TECHNOLOGICAL DEVELOPMENT by R.H. Nunn

This report provides a review of the history of marine gas turbines (MGTs) as propulsors for the Royal Navy, and some of the technological extensions that now appear to be especially promising. Beginning with the Gatric engine in 1943, successive engines are described which, in 1967, provided the confidence necessary for the UK to opt for total MGT propulsion in future naval surface craft. The developments from 1967 onward are briefly summarized, and the current state-of-the-technology is described. Special attention is given to gas generators and their associated ducting systems for use aboard ship.

R-2-77 MATERIALS RESEARCH AT UNIVERSITIES--EN FRANCE ET/UND IN DEUTSCHLAND by A. Sosin

Research activities in materials science and in solid-state physics at two German and two French universities have been reviewed. These universities are the University of Saarlandes, the University of Karlsruhe, the University Louis Pasteur (Strasbourg), and the University of Paris. An account of some of these research activities is given. In addition, we present a discussion of the status of research activities and the stresses imposed on these activities.

C-34-76 IEE INTERNATIONAL CONFERENCE ON MILLIMETRIC WAVEGUIDE SYSTEMS by N.M. Blachman

This report summarizes a symposium on the use of circular waveguides for the long-distance transmission of telephone and related traffic. Conference sessions were devoted to overview papers, waveguide design and production, routing and laying, characteristics of installed waveguides, rf multiplexing, repeaters, active components and devices, systems aspects, and an open forum. It served principally as a forum for the presentation of the work of six countries--France, West Germany, Italy, Japan, the US, and the UK--and it included a visit to the UK Post Office Research Centre.

C-36-76 XIII INTERNATIONAL CONGRESS OF INTERNAL MEDICINE, HELSINKI, FINLAND, 15-19 AUGUST 1976 by M. Stek

This conference was divided into several main sessions focused on the role of bile acids in clinical and iatrogenic disease. These were combined with parallel and free papers devoted to a wide range of subjects in internal medicine. Sessions of particular interest dealt with infectious disease and clinical immunology.

C-37-76 LATTICE DEFECTS IN IONIC CRYSTALS: REPORT OF 1976 BERLIN CONFERENCE by L.M. Slifkin and J.H. Schulman

Salient problems and recent progress in the study of lattice defects in ionic solids were covered by excellent tutorial reviews and numerous contributed papers. This report gives a general overview of the meeting and briefly summarizes a large fraction of the papers.

C-38-76 POSITRON ANNIHILATION: FROM QED TO NDT by A. Sosin

The use of positron annihilation as a tool is showing a remarkable growth in a number of areas: chemistry, materials science, biology, etc. The Fourth International Conference on Positron Annihilation, held at Helsingor, Denmark on 23-26 August 1976 brought together investigators from each of these areas, as well as those in positron physics itself. This report summarizes the presentations at the meeting and attempts to emphasize the highlights of the developments in the field of positron annihilation. As a preliminary to the conference review, this report also provides an introductory survey of positron physics and experimental methods for readers largely unfamiliar with positron annihilation.

C-39-76 INTERNATIONAL CONFERENCE ON RADIATION EFFECTS IN SEMICONDUCTORS by N.D. Wilsey and J.H. Schulman

Selected papers given at this Conference are briefly reviewed. The meeting emphasized how much is still unknown concerning the nature of defects in semiconductors other than silicon, as well as the need to develop other microscopic probes for investigating materials that are not readily amenable to ESR studies.

C-40-76 INTERNATIONAL CONFERENCE ON HYDROGEN AND ITS PROSPECTS by W.G. Soper

Papers from the International Conference "Hydrogen and Its Prospects" Liege, Belgium, 15-18 Nov. 1976, are reviewed for their contribution to future production and utilization of hydrogen as a fuel. Principal emphasis is placed upon the production of hydrogen by electrolysis and thermochemical decomposition of water, and upon the comparison of these processes with synthetic fuel production from fossil resources. Other topics discussed include hydrogen storage and its use as fuel in automobiles and aircraft.

C-1-77

SYMPOSIUM ON THE STRUCTURE OF NON-CRYSTALLINE MATERIALS

by P. Craig Taylor

In this symposium, which attracted contributions from both the amorphous semiconductors and the glass sciences communities, recent results were presented concerning the structure of non-crystalline solids as deduced from several different experimental techniques. These techniques include x-ray diffraction, extended x-ray absorption fine structure (EXAFS), infrared and Raman spectroscopy, low temperature specific heat, and electron spin resonance (ESR). The symposium featured discussions of recent EXAFS measurements and methods of data reduction, of defects in semiconducting and oxide glasses, and of structural modeling techniques including continuous random network models.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